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THESIS

IMPROVING NAVAL AVIATION MAINTENANCE QUALITY MANAGEMENT PROCESSES AT THE ORGANIZATIONAL MAINTENANCE LEVEL: THE INFLUENCES OF THE INTERNATIONAL STANDARDS ORGANIZATION (ISO) 9000 QUALITY MANAGEMENT SYSTEM ON THE NAVAL AVIATION MAINTENANCE PROGRAM (NAMP)

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This thesis examines the similarities and differences between the Naval Aviation Maintenance Program (NAMP) and International Standards Organization (ISO) 9000 quality management systems (QMS), discusses the difference in quality management discipline under ISO 9000 and under the NAMP, and describes what must be changed in the aviation organizational maintenance sections of the NAMP to make them consistent with the ISO 9000 QMS. The NAMP is Naval aviation's overall guiding document that outlines command, administrative, and management relationships, and assigns maintenance policy and procedure responsibilities to the respective individuals for management. ISO 9000 is a series of international standards establishing requirements and guidelines for maintaining an organization's quality system. An overview is provided of quality management (QM) procedures, policies, tools, and audits; the NAMP Quality Management System (QMS); the ISO 9000 QMS; and QMS implementation procedures. Next, process maps are described for QM documentation, policies, and procedures under both the NAMP and ISO 9000. Each is compared and contrasted. Then, QM training under the NAMP and ISO 9000 is described, and advantages and disadvantages of each are listed. ISO 9000 QMS implementation issues and performance metrics are discussed. Finally, recommended changes to NAMP QM procedures, processes, and policies are provided.

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I. INTRODUCTION

A. PURPOSE

The purpose of this research is (1) to examine the similarities and differences between the Naval Aviation Maintenance Program (NAMP) and International Standards Organization (ISO) 9000 quality management systems (QMS), (2) to describe the difference between the discipline in managing quality under ISO 9000 and the discipline in managing quality under the NAMP, (3) to discuss which sections in the NAMP that deal with aviation organizational maintenance can feasibly be changed to make them consistent with the ISO 9000 QMS, and (4) to explain the impacts, positive and negative, of making the NAMP more consistent with ISO 9000.

B. AREA OF RESEARCH

This research will discuss how the quality management policies and procedures within the NAMP must be changed to establish a quality management system (QMS) that gives insight, not just oversight, into the quality of Naval aviation organizational maintenance. There are two objectives. First, this research must describe what changes in the NAMP's quality management policies and procedures are needed to (1) make them consistent with ISO 9000 standards and (2) capture the discipline in quality management that is inherent to ISO 9000. In other words, what would the NAMP QMS for squadrons "look like" if ISO 9000 were "passed through it." The NAMP is part of a total integrated Naval aviation system, from the CNO to the squadron. Everything is included, levels

building upon each other. If it were an ISO environment, fertile environment for a robust QM and continuous improvement. Second, the advantages, disadvantages, and feasibility of supplementing the NAMP QMS at squadrons with an ISO 9000 QMS must be examined. Research will include constructing process maps for NAMP and ISO 9000 QMS procedures, analyzing the differences in disciplines inherent to NAMP and ISO 9000 QMSs, and investigating how aviation maintenance activities can more effectively train Airmen and Petty Officers (PO)/maintenance personnel in QMS procedures.

According to W. Edwards Deming, process takes precedence over product. Everyone is a participant in the process and likewise quality is everyone's job. Referring to Appendix A, Deming's "14 Points" defines the factors the form the basis of a best practices QMS. Those factors target the need for a long term viewpoint, continuous innovation, training, and use of statistical process control. In this type of an environment, quality provides strategic contributions to the organization as improved processes bring about improved products and services. [1]

Dr. Laviolette, a student of Deming's and who is currently in charge of shifting the Naval Engine Airfoil Center (NEAC) current QMS to an ISO-9000-compliant one, states that the single most important element of any QMS is the responsibility of a squadron's officers and enlisted personnel/maintenance managers and technicians to actively involve themselves in the building and support of that QMS. Managers, throughout the system, particularly Commanding Officers (COs) and Maintenance Officers (MOs) (the managers at the senior levels in an organizational maintenance activities) must demonstrate personal leadership and consistently intense involvement in

creating and sustaining a customer focus based in clear and visible quality values that are integrated throughout the organization's QMS. They must also strive to build a properly balanced QMS that promotes bringing about continuous improvement. [2]

Given a robust quality environment where the QMS has been thoroughly aligned with the entire organization's goals and objectives, a QMS drives process and product within that environment. However, within the Navy, the NAMP QMS is driven by the environment due to its unique operational needs and requirements. There are endogenous and exogenous factors that currently work against a totally aligned QMS within the Naval environment. Though beyond the scope of this research, these factors need to be addressed.

Dr. Laviolette states that a properly balanced QMS within an organization consists of two distinct quality management (QM) processes: quality control and quality assurance [2]. Present quality control (QC) in a maintenance environment is the inspection of a good or service after it has been produced to ensure that the good or service conforms to an accepted standard. This process relies upon oversight to help manage quality. QC; however, cannot be relied upon alone to manage product or service quality because it is impossible to eliminate quality problems by using solely QC techniques. Quality assurance (QA) is the process of educating production Airmen and Petty Officers (POs) in how to ensure a quality good or service is produced while educating the personnel in the process itself. It addresses the human design factors that must be incorporated into a QMS to make it effective. It is the totality of the planned and systematic actions necessary to provide confidence that a product or service satisfies

quality requirements [3]. This process relies upon insight to help manage quality. It is the same notion advanced by commercial industry of building quality into the production process of a product or service. The two processes, QA and QC, are part of a continuum that is interwoven in support of each other. Maintenance managers in Naval aviation maintenance, with strong support from strong commanders in the chain of command, must change the QMS currently used by balancing and integrating the use of QC and QA techniques. They must support and become actively involved in building this balance into the NAMP QMS. If they do not, they will be unable to enhance the ability of the NAMP QMS to bring about continuous process improvement, allowing maintenance practices to remain static. Thus, they will not be able to improve the ability of Naval aviation organizational maintenance to logistically support aircraft in a cost-effective manner. [2]

C. BACKGROUND

For approximately 40 years, squadrons have managed quality using NAMP guidelines. These guidelines assign responsibilities, discuss program procedures, and establish policies for managing Naval aviation maintenance activities at all levels of maintenance. The NAMP quality management guidelines; however, rely more on quality control and less on quality assurance to manage quality. While the QMS established under the NAMP guidelines has been effective in reducing the number of quality-control-related incidences, the annual number of these incidences is still unacceptably high. For example, aviation squadrons still experience too many problems such as access panels

departing the aircraft in-flight and fuel tank jettisons due to fuel not transferring properly. These incidences are not necessarily attributable solely to aircraft design problems. Instead, they indicate the QMS within the NAMP is performing less than optimally. The potential may exist; therefore, to improve the NAMP QMS and to still further reduce the number of quality-control-related incidences in Naval aviation maintenance.

In an era of fiscal restraint, the Navy must provide logistical support, including aviation organizational maintenance, in a more cost-effective manner. If the cost of operating Naval aviation activities continues to escalate, the Navy will be able to buy and maintain fewer aircraft. Also, if aviation maintenance activities are performing maintenance less than optimally, the trend will be for more aircraft to be down for maintenance making fewer aircraft available to support operational commitments around the world. If Naval aviation has too few aircraft to support key military missions, then these missions will be taken away and given to other components in the Department of Defense (DoD), and the future of Naval aviation will be threatened.

The Secretary of Defense (SECDEF) mandated in the early 1990s that DoD adopt the ISO 9000 QMS [3]. Although SECDEF realized that compliance with ISO 9000 could help DoD activities improve cost-effectiveness by improving their QMS, only recently have DoD activities come to the same realization. Naval Air Systems Command (NAVAIR) is one such activity. NAVAIR realizes that enhancing the QMS utilized by squadrons can help reduce the need for spare parts and supplies, reduce the levels of management needed to support aircraft maintenance, and increase system operational availability. NAVAIR is, therefore, studying the feasibility of applying ISO 9000

standards to the current NAMP QMS, particularly at the level of Naval aviation's organizational maintenance activities.

The NAMP requires the use of "continuous process improvement," which the NAMP labels "performance improvement." This is the right direction for the NAMP to take in terms of QM, and it is consistent with Dr. Deming's philosophy of QM. The NAMP; however, does not describe how to achieve continuous process improvement in organizational maintenance and so it tends not to be practiced in squadrons. This is a deficiency that can be corrected by teaching empowered Airmen and POs how to use a methodology or technique similar to Toyota's "five whys" exercise. The "five whys" exercise asks the question "why" as many times as is needed to get to the root cause of a process deficiency. It is further explained in Chapter V.

ISO 9000 is a set of quality standards developed by the European Community and adopted by commercial industry around the world as the standard for building a world-class QMS. These standards accurately reflect, and even help to define, the most current state-of-the-art technology and behavioral processes upon which QMSs can be built. It is a set of agreed upon key elements such as continuous improvement, process ownership, and employee empowerment that should be included in every QMS. The QMS elements in the ISO 9000 series outline "what should be done" without prescribing "how it should be done." This is the same principle advanced by the Total Quality Management/Total Quality Leadership system (TQM/TQL) created by Dr. Deming and adopted by the Japanese as the foundation for building their world class QMSs. Basically, ISO 9000 requires an organization to be sure that it is doing the correct things with respect to

quality management, documenting what it is doing, and then doing what it is documenting. The organization must then use a six-step procedure—assessment, planning, upgrading (or redesigning), implementation, auditing, and continuous improvement—to periodically evaluate how well its QMS functions.

ISO 9000 fits into quality standardization in the sense that it doesn't mandate a higher level of quality. Instead, through standardization, it forces a company to assure in its everyday production and maintenance techniques that what it tells its customers it is producing—in terms of quality and performance—is actually being produced consistently. The ISO 9000 series is different from other quality standards existing in the world today. They are used to develop QMSs for everything from the design of a product to the production of a product to the servicing of the customer after the product has been delivered.

Both commercial and government agencies have realized tremendous benefits of establishing ISO 9000 QMSs for two reasons. First, these robust QMSs provide insight into quality management by incorporating QA into production processes. Insight means that the employees are asking what is the best way to perform a procedure; is the process that governs that procedure adding value to the final product or service and is it promoting a continuous improvement environment [2]. As a result, ISO 9000 QMSs are more efficient than traditional QMSs, like those established under the NAMP, which rely upon oversight and inspection "after the fact" for quality management. Oversight is an inefficient and expensive quality management (QM) method because quality problems are difficult to detect and correct by someone other than the person creating them.

Second, ISO 9000 QMSs are built upon a discipline different than that upon which the NAMP QMS was built. For example, the ISO 9000 QMS relies upon trusting well-trained employees to understand when a process is not producing quality products or services and empowering them to effect change to that process. Well-trained employees are more intimately familiar with the intricate details of a process than managers are and thus, they are in the best position to understand how to improve a process. An organizational configuration must be structured to foster this trust and empowerment and to promote training that helps employees understand processes and know how to improve them. This is characteristic of the Generative Configuration as discussed later in this thesis. Organizational maintenance activities in the Navy, however, attempt to build quality processes solely by routinizing them, which is indicative of a Directive Configuration. When well-trained employees are trusted and empowered with managing quality, quality management training makes Airmen and POs more focused on and committed to continuous improvement in QMSs. Therefore, if the ISO 9000 QMS could improve quality management in squadrons, it should be implemented. It is this discipline inherent to an ISO 9000 QMS that makes production personnel in commercial firms more adept at quality management than Navy personnel.

Although most ISO 9000 companies initially experience around a 10 percent cost reduction because of the improvements they make, reducing costs should not be the focus of implementing an ISO 9000 QMS. The cost reductions are a secondary benefit that often accompanies improvements to a QMS. Other secondary benefits include a reduction in the need for spare parts and supplies, a reduction in the levels of

management needed, an increase in system operational availability, and an improved safety record due to heightened personnel awareness of the proper way to perform processes. First and foremost, companies implementing ISO 9000 should focus on quality and self-improvement. The primary benefits of improving a QMS include:

1. Improved product or service quality;
2. Decreased cycle time for the manufacturing of products or the rendering of services;
3. Reduced product rework;
4. Improved productivity;
5. Reduced man-hours needed to produce a product or service; and
6. Improved training of the work force. [3]

The ISO 9000 standards are oftentimes compatible with an organization's existing quality management procedures. The ISO 9000 QMS is a quality standard rather than a product standard. It does not focus on products or services. It is non-specific in the sense that it does not mandate particular methods, practices, and techniques. When implementing the ISO 9000 QMS, therefore, organizations find that their existing quality management policies and procedures can simply be modified to make them ISO-9000-compliant. The authors believe this is the case for Naval aviation's quality management policies and procedures at organizational maintenance activities.

Changing an organization's QMS is no simple task, however. The breadth of activities and the number of research aspects that must be evaluated to fully change a QMS are immense. Dr. Laviolette says the scope and depth of research that must be

conducted is "bigger than huge." The first task in conducting this research, then, is to pick a logical starting point and establish a basis upon which further research can be conducted. That logical starting point is to describe how and why the NAMP QMS should be changed to make it more consistent with the ISO 9000 QMS and to discuss the impacts of making those changes. This research includes describing the changes that must be made to an organization's current QMS in terms of QM training procedures and measuring the performance of the improved QMS. Proper QM training gives Airmen and POs insight into producing quality products or services, and it provides QM POs/maintenance personnel the techniques that are needed to evaluate the quality of products or services after they have been produced. Performance metrics assist managers in evaluating whether processes are effective at producing quality products or services. All other aspects of implementing the ISO 9000 QMS in Naval aviation maintenance are left for other researchers to examine.

D. RESEARCH QUESTIONS

Primary: How must the NAMP quality management policies and procedures be changed to make them consistent with an ISO 9000 QMS?

Secondary:

1. What are ISO 9000 standards?
2. What are the quality management policies and procedures contained within the NAMP?
3. What is the discipline used to establish QMS procedures that comply with the NAMP?

4. What is the discipline used to establish QMS procedures that comply with ISO 9000 standards?

5. What are the differences in characteristics between the organizational configurations of Naval organizational maintenance activities and ISO 9000 activities?

6. What changes to the organizational configuration of Naval organizational maintenance activities would the implementation of an ISO 9000 QMS require?

7. What guidelines in addition to the NAMP, such as maintenance instructions, manuals, etc., form the basis upon which the QMS at the organizational level is created?

8. Are ISO 9000 standards applicable to QMSs in squadrons?

9. How does the ISO 9000 QMS provide insight into incorporating quality within maintenance procedures, and not just provide oversight of the quality in maintenance procedures?

10. What are the benefits to be gained from developing and implementing an ISO 9000 QMS in Naval organizational maintenance activities?

11. Is there a process map for establishing a QMS under the NAMP guidelines?

12. What is involved in developing a process map for establishing an ISO 9000 QMS?

13. How can training Airmen and POs in proper auditing techniques; a better QM methodology, including more comprehensive QA and QC techniques; and trend analysis improve the efficiency of NAMP-compliant QM procedures?

14. Do all NAMP QMS procedures need to be changed, and if not, which ones? If so, which ones?

15. How will replacing NAMP QMS procedures with ISO 9000 QMS procedures make the training of Airmen and POs in quality management more effective?

16. What characteristic(s) of training in an ISO 9000 QMS makes it better in terms of the quality management performance of Airmen and POs than training conducted under the guidelines of the NAMP QMS?

E. SCOPE OF THE THESIS

The scope will include: (1) a review of the differences in organizational configurations between Naval organizational maintenance activities and ISO-9000-compliant activities (2) a review of NAMP QMS procedures outlined in Volumes I and V, (3) a review of ISO 9000 QMS procedures pertaining to aviation maintenance, (4) a review of the quality management training under ISO 9000 and the NAMP at the organizational maintenance level, (5) an evaluation of ISO 9000 quality management policies and procedures as a supplement to the NAMP quality management policies and procedures, and (6) a feasibility study of training Airmen and POs in aircraft maintenance in ISO 9000 quality management policies and procedures at activities.

This thesis is addressed primarily to the military aviation maintenance community and secondarily to the commercial aviation maintenance communities. The term "squadrons" will be used to signify all Naval aviation organization maintenance activities including squadrons, organizational maintenance departments, and other activities associated with aviation organizational maintenance. Organizational maintenance signifies on-aircraft work. The terms "COs and MOs," "Officers and Chiefs," and "Airmen and PO" will be used to signify senior managers, managers, and maintenance technicians/personnel, respectively, in the management chain of command of organizational maintenance activity.

F. METHODOLGY

The methodology used in this thesis research includes the following steps:

1. Conduct a literature search of books, magazine articles, CD-ROM systems, and other library information resources to form a fundamental understanding of the basic tenets of the of a QMS to aid in the comparison and contrasting of the tenets in the NAMP and ISO 9000 QMSs.

2. Conduct a thorough review of ISO 9000 standards. This includes attendance of an ISO 9000 Implementation Strategy Conference.

3. Conduct a review of the current NAMP QMS procedures and program elements and current training of Naval aviation QM POs (e.g., Collateral Duty Inspectors, QM Representatives, etc.)

4. Examine current maintenance procedures and their relationship to quality management at Naval aviation organization maintenance activities.

5. Conduct visits to ISO 9000 certified commercial aviation maintenance/production activities to discuss strategies for implementing ISO 9000 QMSs.

6. Conduct visits to Navy ISO 9000 certified sites to examine the feasibility of implementing ISO 9000 standards at squadrons.

7. Prepare process maps of quality management procedures under the NAMP and under the ISO 9000 standards.

8. Identify quality management training requirements under the NAMP and ISO 9000 standards.

9. Prepare a feasibility analysis for implementing ISO 9000 standards at squadrons.

10. Evaluate the advantages and disadvantages of supplementing the NAMP QMS in Naval aviation maintenance activities with the ISO 9000 QMS.

G. THESIS ORGANIZATION

Chapter I introduces and identifies the purpose, area of research, background, research questions, scope, and methodology used for this thesis. Chapter II provides the methodology/literature review used to develop the following chapters. Chapter III provides an overview of Quality Management (QM) procedures and policies.

Specifically, it discusses the NAMP, ISO 9000, QM tools, QM audits, and implementation of QM programs. Chapter IV discusses how to develop process maps for quality management under the NAMP and ISO 9000, describes the documentation needed for process maps of each QMS, and discusses the advantages and disadvantages of each QMS. Chapter V discusses training in QM procedures for the NAMP and ISO 9000 and describes the advantages and disadvantages of training under each QMS. Chapter VI discusses ISO 9000 QMS implementation issues and performance metrics as related to changes in NAMP quality management procedures and policies at the organizational maintenance level. Chapter VII summarizes the conclusions and recommendations that can be drawn from this thesis and recommends areas for further study as derived from this research.

H. BENEFITS OF THE STUDY

ISO 9000 is applicable to all organizations regardless of whether they are product-oriented, service-oriented, commercial organizations, non-profit organizations, or military organizations. As a result, this study can benefit all Army, Navy, Air Force, and other DOD maintenance activities by providing an understanding of the ISO 9000 QMS and how it impacts existing QMSs. By providing information about how to bring the NAMP QMS procedures into compliance with ISO 9000 standards and information about how ISO 9000 standards will improve or degrade existing quality management policies and procedures in the NAMP, this thesis serves as a reference for other DOD maintenance

activities. These activities can directly and indirectly apply its recommendations to help them implement ISO 9000 standards and improve their existing QMSs.

II. METHODOLOGY/LITERATURE REVIEW

A. INTRODUCTION

This chapter presents a general overview of major QM-related topics, the NAMP, and ISO 9000. Because a piecemeal approach toward implementing a strong and cohesive QMS is almost a certain guarantee of failure [4, p 14], organizations must understand the importance of these topics as they relate to the effectiveness of a QMS. Selecting the appropriate QMS and deciding how it should be implemented are the key starting points to achieving superior quality performance. Each organization must decide which combination of attributes described within these topics can be used to build a QMS that best suits the needs of the organization. The most successful companies design their own pathways and timelines for implementing selected models. [4]

B. NAVAL AVIATION MAINTENANCE PROGRAM

Naval Operations (OPNAV) Instruction 4790.2, the NAMP, outlines command, administrative, and management relationships in Naval aviation maintenance and assigns maintenance policy and procedure responsibilities to the respective individuals for management and task completion. It is a comprehensive and encompassing instruction for performing aeronautical equipment maintenance and related support functions. Because it provides overall guidance, all other directives and instructions concerning Naval aviation maintenance are subordinated to the NAMP. [5]

The NAMP's roots begin earlier than the formal creation of that document. Its foundation was established on the basis of the principles of maintenance promulgated by Air Force's Air Force Manual AFM-66-1. AFM-66-1 laid out a maintenance management plan for all platforms, aviation and non-aviation alike, that called for maintenance actions to be divided among three levels of maintenance. The Navy adopted this foundation and inculcated it into the Standard Naval Maintenance Material System which was later changed to the Maintenance and Material Management (3-M) System. When Naval Officers and Chiefs determined that the special requirements of supporting and accomplishing aircraft maintenance and the special need to particularly emphasize safety in aviation necessitated that a separate standardized maintenance management document for aviation be established within the 3-M System, they created the NAMP.

Established by the Chief of Naval Operations (CNO) and implemented in October 1959, the NAMP has been revised several times to incorporate improved maintenance management processes and techniques. The Naval aviation Maintenance and Material Management (3-M) system was introduced in 1965. It provided direction for maintenance data collection, man-hour accounting, and aircraft accounting. In 1968, the CNO called for a major revision, updating, and issuance of a consolidated directive publication for the NAMP. The 3-M system and all other directives of the NAMP were combined and were issued in 1970 as a cohesive publication labeled OPNAVINST 4790.2. [5]

The NAMP is divided into five volumes that provide overall, general guidance within Naval aviation maintenance. Volume I of the NAMP describes concepts, policies,

and the organizational structure of the NAMP and assigns responsibility for each of its functional area. Volumes II through IV provide general guidance for Depot level maintenance, maintenance data system, and data processing requirements, respectively. Chapter III will provide a comprehensive description of the QMS contained within the NAMP. [5]

The latest revision, OPNAVINST 4790.2G, adds a new Volume V that contains the Naval Aviation Maintenance Program Standard Operating Procedures (NAMPSOP) for 23 standardized programs found in all Naval aviation maintenance activities. NAMPSOPs establish policies, responsibilities, and requirements for the 23 programs defined in the NAMP as being uniform and universal to all aviation maintenance activities. This new volume also establishes the Computerized Self-Evaluation Checklist (CSEC) as the method of accomplishing audits. [5]

The objective of the NAMP is to meet and exceed readiness and safety standards established by the CNO. To meet this objective, the NAMP requires the use of "continuous process improvement," which the NAMP labels "performance improvement." [5] The NAMP, however, does not describe how to achieve continuous process improvement in organizational maintenance and so it tends not to be practiced in squadrons.

C. QUALITY MANAGEMENT SYSTEMS

The quality of a product can be thought of as the degree to which it satisfies a customer's stated or implied needs. A product or service can only be characterized as

having quality when an organization builds an effective QMS to facilitate the emergence of quality [8]. An effective QMS is characterized by two attributes: (1) it is constructed with consistent and intense support and involvement by managers, particularly squadron COs and MOs in an organizational maintenance activity, and (2) it is properly balanced in its use of two distinct quality management (QM) processes: quality control and quality assurance [2].

First, recall Dr. Laviolette's comment that the single most important element of any QMS is management's responsibility to and active involvement in building and supporting that QMS [2]. The consistency and intensity of management's involvement in process improvement directly correlates to how well and how quickly improved processes can be implemented. If management does not accept its responsibility to build and support a QMS, an organization's QMS cannot be effective in bringing about continuous process improvement. Officers and Chiefs cannot allow their commitment to support a given operational tempo to consume their attention to the detriment of improving the processes and QMSs of their organizations. Employees cannot produce products that on the average exceed the quality of what the process is capable of producing. Officers and Chiefs, particularly squadron COs and MOs, must demonstrate personal leadership and involvement in creating and sustaining a customer focus and clear and visible quality values and in integrating these quality values into the organization's QMS. [4]

Second, an effective QMS is properly balanced in its incorporation both aspects of managing quality—QC and QA [2]. QC is the operational techniques and activities an organization uses to ensure its product or service conforms to the organization's

established quality standards. A primary objective of quality control is to ensure conformity specifications are met throughout the maintenance task or process. These conformity specifications are measured using various inspection and test functions after a good or service has been produced [8]. QC, therefore, relies upon oversight to help manage quality [2].

QA includes all the planned and systematic activities implemented within the QMS and demonstrated as needed to provide adequate confidence that an entity will conform to the organization's quality standards [3]. In other words, it is the process of educating Airmen and POs in how to ensure a quality good or service is produced. It addresses the human design factors that must be incorporated into a QMS to make it effective. When properly incorporated into a QMS and practiced proficiently, QA can provide the utmost quality, lower quality control costs, and even reduce the need for QC [8]. It does this by giving Airmen and POs insight and empowerment into building quality into a process [2].

Quality management is defined as the overall management functions that determine the quality policy, objectives, and responsibilities and implement them by means such as quality planning, quality control, quality assurance, and quality improvement within the QMS. [6]

Almost every organization has a QMS such as ISO 9000, TQM, Japan's Industrial Standard, or a hybrid tailored to the activity's quality needs. The QMS is designed to institutionalize a standard set of quality processes so that they can become a way of life within the organization. Most organizations have found that success comes from

focusing on doing things right the first time, on time, every time, and always to the customer's satisfaction. To compete today, every organization needs to have a QMS that sets performance standards (rules) that are well known and rigidly followed to ensure the customer receives the same quality product time and time again. [6]

QMSs are developed to encompass the many attributes of quality activities. Several models are available from which to choose quality activities including those developed by Deming, Juran, Crosby, and ISO 9000 standards [4, p 15]. A successful set of quality activities include an organizational environment that fosters quality, the understanding of the principles of quality, and an effort to engage employees in the necessary activities to implement quality. [6]

An effective QMS is a prerequisite for an effective improvement process. Most activities that choose to implement ISO 9000 standards do so because they want to upgrade, hone, and/or provide a method for continuous improvement of their QMS. The process of upgrading and maintaining a QMS can be divided into a six-phase process. These six (6) phases are assessment, planning, upgrading, implementation, auditing, and continuous improvement. Each of these areas will be presented and discussed in greater detail in a Chapter III. [6]

Every effective QMS must have a strong basis in training, education, and process documentation and must be supported by an organizational structure that is configured to promote continuous process improvement.

D. INTERNATIONAL STANDARDS ORGANIZATION 9000

The term ISO 9000 is used when referring to a series of international standards for QMSs. It is a set of quality standards developed by the European Community and adopted by commercial industry around the world as the standard for building a world-class QMS. These standards can be used by almost any company in virtually every industry from product manufacturers to service providers because they are not unique to any product, service, or industry. The ISO 9000 standards contain requirements and guidelines for establishing and maintaining an organization's quality system. ISO 9000 does not set specifications for a final product. It focuses on the process or how a product is produced. ISO 9000 requires documentation for controlling the process used to reach your final product or service. These standards are based on the assumption that there are certain things every quality system must have in place to produce quality products and services on time. A more comprehensive discussion of the ISO 9000 QMS will be provided in Chapter III. [6]

Organizations like Boeing's T-45TS program that want to take advantage of ISO 9000 standards may choose to become registered, or listed internationally with foreign-government-recognized certification boards that certify an organization is ISO 9000 compliant. A registrar, a person that works for a ISO auditing company, will audit your organization to see if it is meeting all of the ISO 9000 requirements. If it does, the organization will be registered to one of three standards within the ISO 9000 series. ISO 9001 applies to organizations that design, manufacture, and service products. That standard is comprised of the 20 clauses listed in Appendix B. ISO 9002 applies to

companies that manufacture products and/or provide services, but do not design the products. It is the same as ISO 9001 without the Design Control clause, clause 4.4. ISO 9002 is most relevant to the organizational level of aviation maintenance and would therefore be the recommended standard. For example, the T-45TS program is already ISO 9002 registered and can be used by squadrons to benchmark their ISO 9002 implementation. ISO 9003 is used by organizations that focus primarily on final inspection and testing. It contains only 16 of the 20 clauses from ISO 9001. [6] Figure 1 shows the relationship to each other of ISO standards 9001 through 9003.

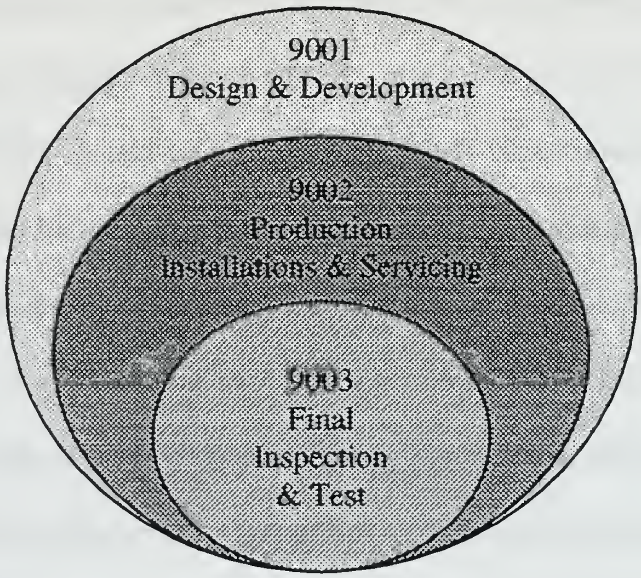


Figure 1. International Standards Organization 9000 Quality Management System Standards. From Ref. [7].

E. PROCESS MAPS

A process is a set of interrelated resources, activities, and tasks that transform inputs into outputs. Process maps provide a graphical representation of activities that make up a process in much the same way that a map represents a particular area. It is a

method of graphically describing an existing process or a new process by using symbols, lines, and words to pictorially display the activities within the process and the sequence in which they occur. [6]

Process maps can provide an excellent basis for analyzing and improving a process, particularly maintenance processes because they can be easily adapted to the diagramming involved in constructing process maps. There are several types of process maps including block flow diagrams, American National Standards Institute (ANSI) standard flowcharts, and functional flowcharts. Documentation of an organization's processes is seldom sufficient to adequately represent the processes, and so it is usually difficult to flowchart every task and activity within the process. Therefore, choosing the appropriate type of process map is the key to an organization's success in documenting an organization's processes. Additionally, an organization must determine how best to diagram the tasks and activities within a process to accurately represent that process. [6]

Quite often, employees deviate from established procedures for a number of reasons. For example,

1. They misunderstand or do not know about the procedures;
2. They find a better way of doing things;
3. The documented procedure is too hard to perform or personnel are not trained to perform it;
4. They were trained or told to perform the procedure differently;
5. They do not have the correct tools or time; and
6. They do not understand why they should follow the procedure. [6]

Many of the aforementioned discrepancies can be solved by using process maps because they help provide a simplified method of accomplishing tasks. Even with little or no training, a process map can provide a concise, easy to follow version of concept descriptions and extensive maintenance task procedures and documentation flow. [6]

Process maps are also a key to business process improvement. Good process charts highlight areas where fuzzy procedures disrupt quality and productivity. Also, because of their ability to clarify complex processes, they facilitate communication about these problem areas. [6]

F. QUALITY MANAGEMENT TRAINING

Quality must be managed by everyone in an organization for the organization's QMS to be optimally effective [7]. Every organizational member; therefore, must understand their role as a quality manager and why their role is important to managing quality. They must feel that they are a part of the quality management process, not just an observer. Consequently, the key elements of quality management training should focus on process control and problem-solving techniques. Many companies accomplish this by teaching employees statistical process controls (SPC) and quality improvement methods.

Managers can make good guesses at what quality problems are occurring from the maintenance activities, but the ones who really know are the employees doing the work. In addition, the employees are in the best position to address, generate solutions, and fix these problems [7]. The opinions and ideas of the employees at the lowest levels in an organization are particularly important to bringing about continuous improvement.

Employees at the lowest levels of an organization are the most intimately familiar with an organization's processes and are, therefore, in the best position to assess how to improve those processes [7]. Managers throughout the organization are in the best position to support, develop, and guide quality improvements to ensure their effectiveness, particularly at the lowest levels of an organization [7]. Therefore, it is important that all members have a thorough understanding of the organization's QMS and that training is tailored to encompass this objective within the entire activity. [9]

Examples of specific quality training programs are many and varied but they can be classified into two general categories. These two categories are general quality awareness training and specific, results-oriented quality training. [4]

General quality awareness training includes items such as the available quality models and how they can be applied, team building, customer focus, effective audit procedures, quality measures, and how to implement a quality process. [4]

Specific, results-oriented quality training includes items such as project planning and control techniques, decision making and analysis, SPC, benchmarking, process flow charting, cause and effect diagrams, and designed experiments control charts. [4] To support a results-oriented QM training program, a thorough and appropriate documentation system is needed.

G. QUALITY MANAGEMENT DOCUMENTATION

The advantages of having a documented QMS that is effectively used far outweigh documentation, installation, and maintenance costs. Advantages include:

1. Providing an understanding of what and who is required to do something;
2. Providing a standard, proven approach to process accomplishment;
3. Providing continuity and a base for process improvements;
4. Providing a base for audits and training newly assigned QM personnel;
5. Providing an excellent communication process; and
6. Providing a way to measure performance. [6]

The reason an organization documents its QMS is to help manage the organization better. The processes and their supporting documents should always reflect the way the management team wants the activity to operate. [6]

The documentation system need not be complex and burdensome to fulfill the organization's or ISO 9000's standards. The better documentation systems are concise, clearly written, simple, easily controlled, and very understandable. The QMS should eliminate unnecessary documentation. Only value-added documents should be part of the QMS documentation. [6]

The ISO 9000 series provides the organization with a great deal of latitude in defining the QMS documentation structure that best meets the activity's needs. There are four primary methods that can be used to organize an ISO 9000 QMS documentation structure. These include process-related, ISO 9000-related, ISO 9000 grouping-related, and ISO 9000 and process combination related. [6]

First, the process-related method creates a structure that parallels the documentation that already exists, but with improvements related to the latest business processes. It documents the existing process flows. It is nothing more than

reengineering, redesigning, or process-benchmarking your QMS. If this is the method an organization chooses to use and wants to be ISO 9000 compliant, it must relate the QM documentation system to the appropriate ISO 9000 standard clauses before it can be registered. This is normally accomplished by establishing a quality manual separate from the current business process documentation. [6]

Second, the ISO 9000-related method is designed around the specific ISO 9000 documentation that the organization has defined as applicable. The QM documentation will follow the same sequence as the ISO 9000 clauses (4.1 to 4.20). This approach normally involves restructuring the entire QMS around ISO 9000 standards. [6]

Third, the ISO 9000 grouping-related method is designed around grouping related clauses into common areas. As an example, these groupings may be divided into management, QMS support, process management and control, and process and system improvement (see Appendix B). Whereas, management may include clauses 4.1, 4.2, and 4.18; QMS support may include 4.5, 4.7, 4.8, 4.11, and 4.16; process management and control may include clauses 4.3, 4.4, 4.6, 4.9, 4.10, 4.12, 4.15, 4.19, and 4.20; and process and system improvement would include clauses 4.13, 4.14, 4.17. [6]

The fourth documentation structure is the ISO 9000 and process combination-related QM documentation method. This method keeps the organization's processes (or improved processes) in place and directly relates the appropriate ISO 9000 standards. This allows the QM activities to be integrated into the organization's operating manual. [6]

An ISO 9000 and process combination-related QM documentation method is preferred. This approach allows the quality management activities to be integrated into the organization's operating manual (i.e., the NAMP) instead of being set aside as separate activities. Each of the clauses of ISO 9000 are joined with the relevant sections that apply to a related activity. [6]

Having appropriate QM training and process documentation methods in place is not enough; however, for a QMS to be effective. The QMS must be supported by an organizational configuration that promotes continuous process improvement.

H. ORGANIZATIONAL CONFIGURATIONS

The effectiveness of a QMS is strongly influenced by the type of configuration the organization employs. An organizational configuration is the structure behind an organization from which emerges distinct characteristics and coherent patterns. It is a clustering of organizational attributes grouped together in such a way as to optimize efficiency—the capacity to produce results—and/or effectiveness—the capacity to produce results with the minimum expenditure of resources. Four separate organizational configurations are distinguishable: Directive (D), Responsive/Political (R/P), Adaptive (A), and Generative (G). Figure 2 shows the relationship of each configuration relative to its focus on achieving efficiency and/or effectiveness. [20]

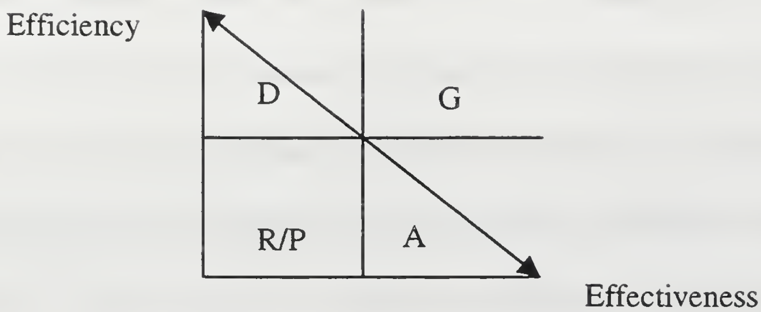


Figure 2. Relative Efficiency/Effectiveness of Four Organizational Configurations. From Ref. [20].

The Directive Configuration is characterized as a well-oiled machine with a centralized, top-down approach to management. Coordination is achieved through the hierarchy, a well-trained force of specialists, and standard operating procedures (SOP). This configuration attempts to control the working environment by standardizing and routinizing tasks. Managers take on a role of strategic planner and controller. They minimize the occurrence of issues of adaptation and collaboration because change disrupts orderly operations. When it is necessary for the organization to undergo change, the organization's strategic apex issues directives to change the SOPs. Organizations that utilize the directive configuration are grouped into rigid, functional areas of expertise and attempt to optimize efficiency, not effectiveness. Many DoD activities strongly exemplify this organization [20]. [21]

The Responsive/Political Configuration attempts to optimize neither efficiency nor effectiveness. In some management situations within this configuration, efficiency is the objective, and in others, effectiveness is the key objective. It is characterized by a management approach that attempts to establish a power base through maneuvering and

alliances. This organization "...produces an inconsistent, disjointed pattern of activity in response to the demands of the political environment." [20, p 9] "The policies that emerge are the result of partisan mutual adjustments." [20, p 9-10] The manager can be thought of as a firefighter. Congress is a good example of an organization that employs the Responsive/Political Configuration. [20]

The Adaptive Configuration is characterized by a decentralized management approach that adapts to a changing environment by "groping along." Adaptive organizations try to keep the whole organization flat. Managers in this configuration optimize effectiveness, not efficiency. They encourage innovation and creativity and craft a vision that establishes broad boundaries for organizational action. They take on the role of champion of innovation. Effectiveness is achieved by coordinating multi-functional teams of experts in learning through creative experimentation. These ad hoc teams use the experts' knowledge and skills to find new opportunities to exploit. Examples of organizations operating in the adaptive configuration include high-tech software companies such as Netscape and Apple. [20]

The Generative Configuration is characterized by a decentralized management approach that attempts to facilitate learning and collaboration. Its basic elements include a boundaryless structure that optimizes efficiency and effectiveness through stakeholder collaboration and a process of learning. Coordination is achieved through information-sharing networks that are centered around a strategic issue and accepted standards of conduct that support the learning process. Learning is achieved through "...joint problem solving rather than fault finding, listening rather than attacking, sharing of information

rather than secrecy and suspicion of differences." [20, p 24] Managers take on the role of steward. Typical features of the Generative Configuration include outsourcing non-core elements, long-term partnering relationships, extensive use of information technology, exploitation of global markets, strategic flexibility, self-managing teams, and process improvement [22]. General Electric and Toyota are examples of organizations that attempt to utilize the Generative Configuration (there is currently no organization that perfectly emulates the Generative Configuration [21]). [20]

It is also possible for organizations to be structured in a hybrid configuration. Although organizations structured in a hybrid can perform well, organizations structured solely around one of the four ideal configurations can perform better. Also, there is another drawback to structuring an organization around a hybrid configuration. Hybrid configurations tend to create inconsistencies, or incongruities, in an organization. These inconsistencies exist between the goals used to set direction for an organization and the organization's systemic characteristics that support the achievement of those goals. [20]

For example, the introduction of the TQM/TQL system into the Navy has brought about little real change. The discipline inherent to the TQM/TQL system is characteristic of organizations that are attempting to structure themselves in the Generative Configuration. Military organizations are typically characterized by the Directive Configuration. The Navy attempted to execute the TQM/TQL system by adopting only some of the elements of the TQM/TQL system. For example, it implemented practices such as the use of quality circles without addressing the cultural changes needed to support the TQM/TQL system. The culture that prevailed in the Navy blinded itself to

the possibilities of improvement that TQM/TQL could bring and therefore prevented the full implementation of the TQM/TQL system [23]. While the Navy was on the right track in adopting the TQM/TQL system, the TQM/TQL system can only function effectively if the system is adopted in its entirety [2]. In other words, the Navy tried to mix organizational elements that are common to Generative Configurations with a culture that is more characteristic of a Directive Configuration [21]. As a result, TQM/TQL has been largely abandoned in many activities in the Navy. [2]

This same argument can be made about how the ISO 9000 QMS should be implemented. Dr. Deming's 14 Points for implementing quality improvement (see Appendix A) form a universal basis for the establishment of the TQM/TQL program and foster quality improvement [24]. The ISO 9000 QMS and TQM/TQL are parallel systems that are founded on these same principles [25]. If squadrons adopt the ISO 9000 QMS without changing their culture, the resulting hybrid configuration may bring disappointing performance again.

Also, the ISO 9000 QMS has elements that are characteristic of both the Directive and Generative Configurations. It relies on process standardization found in the Directive Configuration, yet it calls for the employee empowerment and collaborative partnering relationships found in the Generative Configuration. It can be inferred, therefore, that the ISO 9000 QMS has elements that are characteristic of an organizational structure that is a hybrid between the Directive and Generative Configurations. Despite the disadvantages of hybrid configurations, there is whelming evidence that the ISO 9000 organizations perform well, that is as long as the ISO 9000 QMS is adopted as a whole system.

Because the very nature of ISO 9000 connotes quality improvement, this inherently indicates organizational change. Therefore, to increase the probability of successfully implementing ISO 9000, organizations must carefully manage the change implementation process.

I. CHANGE IMPLEMENTATION

Successful process improvement has two key elements: a better concept and effective implementation. Because squadrons operate in the Directive Configuration where communication flows primarily from top to bottom, it is difficult to solicit ideas about better concepts from Airmen and POs within the organization [20]. Many organizations experience great difficulty in implementing better concepts effectively for the same reason. Change implementation methodology is a helpful tool to use as it focuses on opening the lines of communication and reducing or eliminating the resistance to change that occurs during the transition period as organizations move from one quality level to another. [6]

Implementing change will create a great deal of anxiety and have a major impact on organizational members' current beliefs, behaviors, knowledge, and expectations. The journey from status quo to some distant, possibly unclear future state can be disastrous if not managed properly with appropriate strategies and tactics. Managers must understand the six (6) aspects of facilitating change. First, managers must be able to convince people that change can and must be managed; and that people must give up the current state or status quo and focus on arriving at the future state. The emergence of an organizational

crisis (explained below) is often the catalyst for change. Managers must help their Airmen and POs want to give up the status quo by framing this crisis in such a way that causes them to internalize it [23]. Second, they must help organizational members understand that change is not a one-time event or temporary arrangement and help them move through and deal with the often turbulent transition period. Third, managers must adopt appropriate metrics and measures to help them monitor the success of the change implementation. Appropriate measures and metrics in QM focus on quality improvement, not cost reductions. While cost reductions often accompany improvements to a QMS, this is a secondary benefit. Fourth, managers must develop a method/plan for implementing the change. Fifth, the manager must be adept and knowledgeable of the critical success and failure attributes involved in change. [6]

For example, one of the attributes a manager will be concerned with is the culture or organizational alignment. The manager will want to know how consistent or inconsistent the change is with the existing organizational culture. If the changes require a major shift in the organization's strategy to meet its objectives, then the culture may be a failure attribute and the manager will want to give more attention to this attribute to enhance the probability of successfully bringing about the change. [6]

Another attribute the manager is concerned with is the target response. The manager will want to know how resistant to the change are those individuals who must change the way they work. If the employees collaborated and brought the change idea to management, then the target response can be considered a success attribute and the manager may use the employees support by allowing them to develop the change

implementation procedures that should be used. This allows the manager to focus on other issues. [6]

One such change management methodology is Organizational Change Management (OCM) [6]. OCM assigns change management to three key roles: the initiating sponsor, the change agent, and the change target. The initiating sponsor is the individual or group with the power to initiate or legitimize the change for all affected people in the organization. This is generally a role taken by a Chief Executive Officer by virtue of his position of authority [26]. For Naval aviation, this would likely be N88, Director, Air Warfare Division. N88 has the overall responsibility for establishing the policy, requirements, and priorities for aviation maintenance, including setting direction for naval aviation maintenance through the NAMP.

A change agent is the individual or group that brings the vision for change to the organization. The change agent becomes an individual or group with the responsibility for implementing change and charged with helping the organizational change take place smoothly and effectively. By this time, the crisis, as explained below, has been identified, thus there is a strong motivation for the organization to alter its current behavior to resolve the crisis.

Sometimes, the change agent does not have the power to legitimize the change; s/he only has the vision to see the organization as it might be if the change were implemented. In a case such as this, the initiating sponsor assumes the responsibility for implementing the change, and the change agent provides guidance to the change implementation process based on his vision. The change agent and initiating sponsor can

also be the same person(s). Because NAVAIR is leading the effort to study ISO 9000, the change agent would probably come from within NAVAIR. At the same time, because the initiating sponsor would likely be the N88, a second change agent from within his staff would probably be needed. This would be someone directly involved in NAMP policy and procedure formulation. The change target is the individual or group who must actually change. For purposes of this thesis, the change targets are organizational maintenance activities. To be effective, management must understand how these positions interact and overlap and support each in his/her role to achieve the organization's change requirements. [6]

These roles comprise three of the four elements that must be in place for change to be successfully implemented. Womack and Jones label the fourth element "the crisis" in *Lean Thinking*. The crisis is the event or series of events that force an organization to either embrace change or maintain the status quo and suffer the consequences; the organization comes to a "crossroads." If the organization embraces the change, its operational performance and product or service quality and customer responsiveness may be dramatically improved. If the organization does not embrace the change, it may be forced to accept mediocrity in its product or service. Eventually, it may even cease to exist as it loses customers. In the case of Naval aviation, the crisis is that in the current era of fiscal restraint, if the cost of operating Naval aviation activities continues to escalate, the Navy will be able to buy and maintain fewer aircraft. Also, if aviation maintenance activities are performing maintenance less than optimally, the trend will be for more aircraft to be down for maintenance making fewer aircraft available to support

operational commitments around the world. If Naval aviation has too few aircraft to support key military missions, then these missions will be taken away and given to other components in the DoD, and the future of Naval aviation will be threatened. Therefore, logistical support, including organizational maintenance, must be provided in a more cost-effective manner. Without having all these elements in place, the probability of successfully implementing change decreases because while each of these elements is necessary to the success of change implementation, existing individually, they are not sufficient to ensure change is successfully implemented. [26]

Sixth, management throughout the organization must not only mandate change but must also support and sustain the change objectives over the long term. One of the common pitfalls associated with implementing change is an assumption that once the decision has been made and communicated regarding what must be implemented, no further involvement by management is necessary. Additionally, quite often change decisions are blocked and never heard from again. A manager who does not support the change normally causes this situation, and so the individuals below him/her do not see or adopt the change. To counter this situation, management may require that the initiating sponsor, change agent, and target agents work as a synergistic and overlapping team to ensure collaboration and open communication. [6]

Resistance is any opposition to a shift in the status quo and is a common, natural response to change. Quite often, resistance will begin as soon as change is initiated and can be expressed overtly or covertly. The amount of resistance will vary amongst

individuals depending on their perspective of the impact that the change will have on them and their job. Other factors that cause resistance to change include:

1. Confusion about how the change should be implemented;
2. A poor implementation strategy (can be viewed as the flavor of the month);
3. No consequence management (holding people accountable for effecting change) to accompany the change; and
4. Too little time being devoted to the change. [5]

Managers must understand how this resistance hinders change implementation, but they must not overreact when this resistance emerges. Instead, they must work steadily to build commitment from those that are resisting the change to the level necessary to ensure the change implementation is successful. [6]

J. CHAPTER SUMMARY

DoD is attempting to enhance the cost-effectiveness of its operations by improving its quality management processes. Many DoD activities are realizing that carefully scrutinizing and improving the effectiveness of their existing QMS is a key to the success of their efforts. Managers cannot hope to improve a QMS unless they improve QM training and documentation processes, and have a clear understanding of the six (6) aspects of change implementation in quality management. They must also have an understanding of the general aspects of quality management.

The ISO 9000 standards form an excellent QMS to improve the NAMP as it brings a new discipline to Naval aviation maintenance. This new system will be

consistent with current practices in commercial aviation maintenance. To understand why this new QMS is proving to be successful at improving QM, the elements such as QM audits, QM training, and SPC that make up an effective QMS must first be studied.

The next chapter will provide an overview of QM procedures and policies. It will describe the basic tenets in both the ISO 9000 and NAMP QMSs and describe the basic tools that should be incorporated into an effective QMS. These tools include an auditing system, Pareto analysis, cause-and-effect diagrams, and SPC. Finally, issues concerning the implementation of a QMS are discussed.

III. OVERVIEW OF QUALITY MANAGEMENT PROCEDURES AND POLICIES

A. INTRODUCTION

Quality is a term that means different things to different organizations. In general, it can be defined as "the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs." [24]

This chapter presents an overview of QM procedures and policies. Effective QM procedures and policies should help an organization achieve continual process improvement. Typically, process improvements at the organizational level of maintenance in Naval aviation focus solely on increasing operational availability and sortie completion rates while reducing costs. This mentality is counter-productive, however. Research data from classroom training and comparisons of other organizations, both civilian and military, suggests that there is a more effective way to bring about continuous improvement in Naval aviation maintenance.

The primary goal of aviation maintenance should be to continuously provide the highest quality product (aircraft and related systems maintenance production) while improving maintenance processes and ensuring that the maintenance activity achieves the utmost efficiency. By giving maintenance Airmen and POs quality insight into day-to-day maintenance processes and procedures, this goal can be achieved.

The data in Tables 1 and 2 indicate that Class "A" mishaps and incidents of Things Falling Off Aircraft (TFOA) continue to occur. According to the Naval Safety

Center, the goal of naval aviation maintenance should be to have no Class "A" mishaps or TFOAs because these incidences and mishaps lead to Airmen and POs injuries and property damage [27]. Class "A" mishaps are accidents involving loss of life or $1 million or more in damage. Worse yet, the annual numbers of TFOA occurrences shown in Table 2 are just the reported totals. Navy maintenance activities generally report only TFOA incidents where damage and/or injuries to government and/or civilian property and personnel occur. The actual annual number of TFOA occurrences is probably higher.

As can be seen in Tables 1 and 2, there are highs and lows in the data. Due to inadequacies in the data collection methodology at the Naval Safety Center, it is difficult to identify the specific causes for these fluctuations. Contributing factors to these fluctuations vary widely and include variances in the total number of flight hours from year to year, variances in the types of missions being flown from year to year, changes in aircraft platforms and configurations, and changes in pilot and maintenance technician training. Identification of the specific causes of the highs and lows seen in Tables 1 and 2 is beyond the scope of this thesis and is therefore the subject of further thesis research. The totals in Tables 1 and 2; however, are not inconsistent with the range that has been seen since before 1994, and the Naval Safety Center hypothesizes similar results since before 1989. [27]

Year	Total Flying Hours	Class A's	Rate (per 10,000)
CY 94	1,637,988	31	1.89
CY 95	1,670,015	30	1.8
CY 96	1,626,448	40	2.46
CY 97	1,519,549	25	1.65
CY 98	1,500,150	33	2.2
Total	7,954,150	159	2.00

Table 1. Annual Class "A" Mishap Totals. From Ref. [28].

Year	# of TFOAs
CY 94	1529
CY 95	1357
CY 96	1797
CY 97	1666
CY 98	1517
Total	7866

Table 2. Annual Reported Things Falling Of Aircraft Totals. From Ref. [28].

Although conclusions about the occurrence of flight mishaps and incidences due to quality problems in Naval aviation organizational maintenance cannot be drawn directly from Tables 1 and 2, data which do correlate more closely with these problems is not readily available. Therefore, the data in Tables 1 and 2 are the best data available from which conclusions can be drawn about quality management problems. [28]

These data in Tables 1 and 2 are useful in two ways. First, the annual totals shown in Tables 1 and 2 have been relatively stable for at least 5 years, and the Naval

Center hypothesizes that the rate of mishap and TFOA occurrences has actually been the case for at least 10 years [27]. This suggests that the capability of Naval aviation maintenance to improve its safety record and to enhance its maintenance practices has probably reached a plateau. Quality management in aviation maintenance must be significantly changed to bring further improvements.

Second, because material discrepancies and maintenance mal-practice stem from quality management problems, the statistics in Tables 1 and 2 are at least indirectly indicative of a quality management problem in Naval aviation organizational maintenance. According to the Naval Safety Center, 20 percent of the mishaps listed in Table 1 involve factors that include aircraft material discrepancies and maintenance mal-practice. Officers and Chiefs in Naval aviation organizational maintenance agree that the percentage of TFOAs listed in Table 2 and caused by aircraft material discrepancies and maintenance mal-practice is even higher. [27]

According to the Naval Safety Center, the aviation mishaps and incidences caused by quality problems are separated into various categories including mishaps caused by material failures and maintenance malpractice, and mishaps caused by human factors. Aviation mishaps and incidences caused by quality problems are not tracked separately. Both the separate categories for mishaps caused by material failures and maintenance malpractice and mishaps caused by human factors do not separate mishaps where poor quality management is involved from mishaps where it is not. Also, while mishap/incident investigators determine whether a mishap is related to maintenance malpractice or material failure, they do not currently link the maintenance malpractice or

material failure to poor quality management when poor quality management is the root cause. [27]

Also, the Maintenance Data System (MDS) in Naval aviation maintenance is used to collect data about maintenance actions that stem from quality problems in organizational maintenance, repeat or other quality-related discrepancies. These data are currently accessible through an "ad hoc" query in the Naval Aviation Logistics Command Management Information System (NALCOMIS), but it is difficult to retrieve and group into meaningful metrics. Organizational maintenance activities already perform the NAMP-required categorization of data that is related to QM problems, but this is scant and not very revealing of QM problems. Additionally, Airmen and POs are not trained in how to group these data into meaningful metrics or perform trend analysis on the data. These data are, therefore, simply not categorized at the organizational maintenance level into meaningful metrics from which these conclusions about quality problems can be directly drawn. [29]

Quality problems do not seem to stem from complacency but from the rush of daily business [2]. A contributing factor to the quality management problems in Naval aviation organizational maintenance is the disproportionately high number of unscheduled maintenance actions to scheduled maintenance actions. Unscheduled maintenance actions cannot be anticipated and force Officers and Chiefs to assume a reactive role. Examples include structural inspections for hard landings or the removal of a component that fails before the end of its expected service life or allowable operating period. Scheduled maintenance actions can be anticipated and managed by planning.

Examples include corrosion inspections, the removal of a component that has reached the end of its service life or allowable operating period, or the anticipated removal of a component that fails prematurely.

An effective QMS can help maintenance managers control the occurrence of unscheduled maintenance. For example, the aircraft maintenance workload at United Airlines is comprised of mostly scheduled maintenance actions, with a low ratio of unscheduled to scheduled maintenance actions, approximately 0.3 [25]. In other words, United Airlines maintenance workload typically consists of less than one third as many unscheduled maintenance actions as scheduled maintenance actions. Although the ratio of unscheduled to scheduled maintenance actions in Naval aviation organizational maintenance is not tracked and is therefore difficult to quantify, most Officers and Chiefs in Naval aviation agree the ratio is high, approximately 4.1 [19]. In other words, the workload in Naval aviation organizational maintenance is comprised of over four (4) times as many unscheduled as scheduled maintenance actions. A complete discussion of the underlying causes for the difference in these ratios between United Airlines and Naval aviation organizational maintenance is beyond the scope of this thesis. Nevertheless, a high ratio of unscheduled to scheduled maintenance introduces significant variability into a maintenance workload thus making Officers and Chiefs more likely to operate as a crisis manager and less likely to concentrate on managing maintenance quality. [14]

Three consequences result from having a high ratio of unscheduled to scheduled maintenance actions. First, maintenance technicians become "firefighters," constantly reacting to the need to complete unscheduled maintenance. They are pushed to their

limits of endurance and their morale is then negatively impacted. Second, a large degree of variability is introduced into the organizational maintenance activity's ability to conduct maintenance properly and meet its operational commitments. Maintenance activities are forced to plan maintenance with an events-driven approach, instead of a forward-looking, systematic approach. Third, because they focus on reacting to maintenance requirements, maintenance activities place limited emphasis on training Airmen and POs to solve complex tasks and create new and improved ways of meeting commitments and goals.

Further exacerbating this problem is the frequent rotation of Airmen and POs in military activities. High personnel turnover rates limit the availability of technical skills and experience, inhibits the organizational maintenance activity's ability to transition from an events-driven (fire-fighting) maintenance planning approach to a systematic approach, and disrupts the continuity in resolving any ongoing problem [30, p 9].

The existing quality management problems in Naval aviation maintenance cannot be ameliorated without introducing a new paradigm in thinking about quality management [7]. Officers and Chiefs who exhibit this paradigm identify underlying processes that cause quality problems instead of placing blame, focus on continual process and procedural improvements instead of relying on the "that-is-the-way-we-have-always-done-it" mentality, and realize the value of properly trained Airmen and POs instead of allowing operational commitments to dominate training time. They do not allow their commitment to support a given operational tempo to consume their attention to the detriment of improving the processes and QMSs of their organizations. The

process of becoming ISO 9000 compliant helps bring about this change in paradigm because the ISO 9000 QMS forces managers to evaluate whether the processes that are in place are the best that could be used. [2]

Recently, considerable emphasis has been placed on evaluating initiatives that can be used to countermand problems with managing quality. The ISO 9000 QMS is one such initiative that can be applied to Naval aviation's organization maintenance activities. ISO 9000 focuses everyone's attention in an organization, particularly at the lowest levels, on looking critically at the existing quality management system to discover how existing processes can be continuously improved. It also standardizes operating procedures across an organization lessening the variability in organizational process, thus helping an organization's ability to meet the additional operational commitments introduced by personnel rotation.

Some of the improvements it brings include enhancements to QM training, better use of data evaluation techniques such as SPC, and the conducting of more effective audits. It can be used to ensure quality is supported by and built into every aspect of maintenance in squadrons.

B. NAVAL AVIATION MAINTENANCE PROGRAM AND QUALITY MANAGEMENT

A properly functioning QMS encompasses all aspects of an activity as well as everyone in the organization from top to bottom. When redesigning a QMS, primary

attention should be given to the QA division and maintenance training since these are the elements that are the most critical to the success of a QMS.

Within Naval aviation maintenance, these elements are described in several different sections of the NAMP. Chapter 14 of Volume I describes the QA concepts that relate to organizational maintenance activities and discusses the responsibilities and functions performed by the QA division. Chapter 20 provides training policy, information on types of training, training support methods, and training support activities. [5, Vol. I, p 2-1]

The NAMPSOPs, as defined in Chapter II, that are in Volume V of the NAMP list the programs that an organizational maintenance activity's QA division must monitor/manage. One of these NAMPSOPs introduces, discusses, and defines responsibilities for a QA audit program. This NAMPSOP requires that Computerized Self Evaluation Checklists (CSEC) be used to perform audits and that audits be performed at three levels: at the level of the Type Commander (the Aviation Maintenance Management Team (AMMT)), at the level of the Type Wing, and within maintenance activities themselves. Another NAMPSOP establishes policy, responsibilities, and requirements for implementing training within aviation maintenance activities. [5, Vol. V]

The CSEC is used to generate all checklists for audits, provides for collection of discrepancy data, and produces reports which can show whether the maintenance programs at a maintenance activity comply with the NAMP and any other related instructions and publications. The compliance of each maintenance program element is

based upon a "yes" or "no" criteria. Appendix C includes a sample page from a CSEC checklist. [5]

The QMS within the NAMP has seven (7) flaws that make it an ineffective aid to managing quality in organizational maintenance activities. First, although the NAMP requires specific quality management functions to be performed, it provides little guidance on how to measure these functions for efficiency and effectiveness. Second, QM POs have limited access to maintenance data that covers extended periods of time making it difficult to perform trend and other types of analysis. Third, the NAMP requires few procedural feedback loops to assess how effective training is. The Army currently has a system that provides direct feedback from soldiers to Officers after the completion of exercises and that provides electronic database categorization storage of those lessons to be used in future exercises.

Fourth, the NAMP's methodology for meeting aviation readiness and safety standards is "continuous process improvement." While the NAMP describes what "continuous process improvement" in organizational-level maintenance is, it offers few prescriptive measures that can be used to achieve it. Specifically, the NAMP states that its methodology for achieving continuous improvement is "performance improvement." It then defines performance improvement as "...an 'all-hands' effort which focuses on service and close support to customers." The guidance that the NAMP does give is that "continuous process improvement" can be achieved when "...all personnel know their job, understand their contribution to mission accomplishment, and are sensitive to customer requirements." It does not specifically explain how to achieve "continuous

process improvement" in organizational maintenance. A training process for achieving "continuous process improvement" is explained further in Chapter V. [5, Vol. I, p 2-1]

Fifth, the process for recommending and submitting changes and corrections to maintenance-related instructions and publications is cumbersome and fragmented, and it provides an inadequate means of sending feedback to those submitting the changes. A change request is a modification to the existing NAMP policies and procedures. A deviation is a departure from NAMP policies, procedures, or responsibilities. [5, Vol. I, p 1-3] For example, change requests to the NAMP are submitted by Naval letter to an activity that is different than the one to which deviation requests are submitted. Also, changes or deficiencies resulting from incorrect packaging and handling, locally procured material found to be deficient, recommendations for improvement in procedures which do not result from incorrect information contained in publications, NALCOMIS publication deficiencies, and several feedback forms have their own unique reporting procedures. Furthermore, information about discrepancies is not shared between reporting activities, [Vol. I, p 10-2] and is not readily available for Airmen and POs to access during troubleshooting procedures [25].

Sixth, very little QM training is provided to Navy QM POs. They are not taught how to audit correctly. The training that is provided QM POs only familiarizes them with elements of the maintenance programs they will inspect during work center audits. No training is provided on how to identify weaknesses in maintenance processes. No training is provided on how to properly analyze data using SPC or other similar tools. As a result, QM POs base their decisions about discrepancies discovered during audits solely

on intuition or memory instead of basing them on intuition, memory, and facts derived from analysis of comparative data. [5]

Seventh, because organizational maintenance activities focus on accomplishing unscheduled maintenance, maintenance training suffers due to the lack of time available for training and the lack of management support [29]. Maintenance technicians become less proficient in producing quality maintenance.

C. INTERNATIONAL STANDARDS ORGANIZATION 9000 TENETS

The notion that processes and their interfaces should be subject to analysis and continuous improvement is the fundamental base upon which a QMS should be built [6]. The conceptual base upon which ISO 9000 standards are established is this notion. ISO 9000 focuses on principal concepts related to QMSs, management's involvement and review, and treating work as a process that should be documented and controlled. It emphasizes that:

1. Processes should be defined;
2. Procedures should be appropriately documented;
3. The organization should be functioning as documented; and
4. Records should be kept to verify that the procedures are being followed. [6]

ISO 9000:

1. Pushes responsibility to the lowest level. The process users write the processes. A process owner is selected as the responsible agent for each process;

2. Promotes ownership of processes and requires proof of continuous improvement;

3. Requires processes to be documented in "easy to use" process maps;

4. Requires auditor training throughout the activity, not just for QA personnel;

5. Requires that an expert QMS auditor, external to the organization, assess the actual condition of the activities QMS (third party audit). This is done in addition to the required internal audits; and

6. Requires management to be involved in the QMS. [6]

The ISO 9000 QMS is a quality standard rather than a product standard. It does not focus on products or services. It applies to the process that creates them. ISO 9000 is designed and intended to apply to virtually any product or service made by any process anywhere in the world [31, p 6]. ISO 9000 standards are non-specific in the sense that they do not mandate particular methods, practices, and techniques. They focus on one objective and are the key to the success of all world-class businesses. This objective is meeting the customer's expectations and requirements. [31]

Therefore, ISO 9000 can excel in Naval aviation organizational maintenance. All maintenance operations operate similarly. A maintenance requirement is established, and then it must be addressed by Airmen and POs and must have a level of record keeping that is consistent with the maintenance that is being performed. Naval aviation organizational maintenance is a maintenance operation that is specialized around maintaining military aircraft. It requires that everything be well-documented and well-controlled. Regardless of the complexity of the maintenance operation being performed;

however, the ISO 9000 standards will flex to accommodate the needs of the maintenance activity performing the work. [32]

According to Mr. John Wilson of United Airlines, ISO 9000 promotes change. It promotes the use of new and current technology, finding solutions to problems in-house (continuous improvement), and empowerment of the artisan and production personnel to solve problems and develop improved processes. Having procedures in place to identify what you do is the real backbone of the system. In addition, he went on to say that, "you must be able to do what you say you can do." [25]

D. QUALITY MANAGEMENT TOOLS

Recall that in general, quality can be defined as "the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs." [24] After quality standards have been established, quality deficiencies can be identified and resolved using quantitative techniques and tools.

There are a variety of quantitative techniques and tools available that can be used to identify quality deficiencies. These include statistical techniques such as reliability testing, Pareto charts, SPC, fishbone diagram analysis, probability theory, test of a hypothesis, loss-functions, cost/benefit ratios, and Chi-square analysis. Other tools include problem solving techniques that have a statistical element such as quality function deployment, failure mode and effects analysis, and benchmarking. Only the tools that are most likely to be readily useable to squadrons are discussed below. These include Pareto charts, process maps (or charts), cause-and-effect diagrams, and SPC techniques.

The Pareto chart is a graphic way of identifying the few critical process deficiencies, as opposed to many less important ones. It provides a method of organizing errors, problems, or defects to help focus on problem-solving efforts. In addition, it can be used to track processes and the number of times something is done. Figure 3 shows an example of a Pareto chart. In this example, four types of failures are depicted, in this case the most critical or common failures. The most common failure in this example is number one. The Pareto analysis allows the user to visually see and be able to focus on the problem that may provide the greatest payoff when resolved. [24]

A disadvantage of using Pareto analysis is that it only shows the frequency of process deficiencies. It does not show the relative magnitude of importance to operations of the discrepancies that are occurring. Although the objective of the Pareto analysis is to show only the few critical process deficiencies, some of these process deficiencies may be less critical than others. A manager must judge which process deficiencies to include in the analysis and which not to include. For example, although deficiencies in category one may occur more frequently than the deficiencies in the other categories, the deficiencies in category one may have less of an impact on the availability of a system, on the number of personnel injuries that occur due to the deficiency, etc. than the deficiencies listed in the other categories. Managers sometimes miss this distinction. This may mislead a manager to concentrate first on the category with the most frequent occurrence of process deficiencies rather than on the category with deficiencies that have the greatest negative impact on the operation of a system. [24]

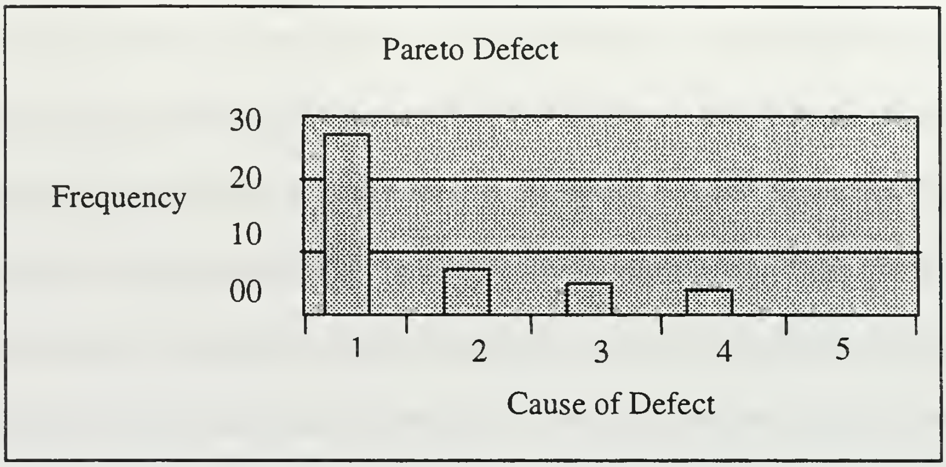


Figure 3. Pareto Defect Analysis. From Ref. [24].

Process maps or charts allow the user to identify and understand a sequence of events. Process charts use symbols to analyze the movement of people or material. The process chart graphs the actual steps of the process and their relationships. This type of analysis can: (1) help identify the best inspection and data collection points, (2) isolate and track the origin of problems, (3) identify non-value added activities such as delays and storage, and (4) identify opportunities for travel-distance reduction. [24]

Process maps are essential tools for identifying processes. In ISO 9000, process maps are used to identify problem areas and to provide a clear, concise, and simplified representation of that activity (see page 64). Chapter IV contains examples of process maps for NAMP and ISO 9000 process flows and documentation processes. [24]

The cause-and-effect (fish-bone) diagram shown in Figure 4, is a schematic technique and is also another way of documenting a process that can be used to identify quality problems and to show where to interject inspection points. Referring to Figure 4, a manager identifies a quality problem by using four M's—material, machinery, methods, and manpower. Individual causes associated with each of the four M's may be tied in as

separate bones along that branch. For example, a hole that has been drilled out of tolerance on an aircraft panel can be linked to a worn bit on a drill press. [24]

A disadvantage of using the cause-and-effect diagram is that it does not provide a fail-proof methodology for identifying the root cause of a process deficiency. Managers must still use intuition to determine the correct parameters to measure in order to identify the root cause of the process deficiency. Returning to the example in the previous paragraph, a machining process results in holes being drilled out of tolerance. The manager might suspect that the drill press is creating the problem when in fact, the drill press operator is not properly trained in adjusting the drill press for operation.

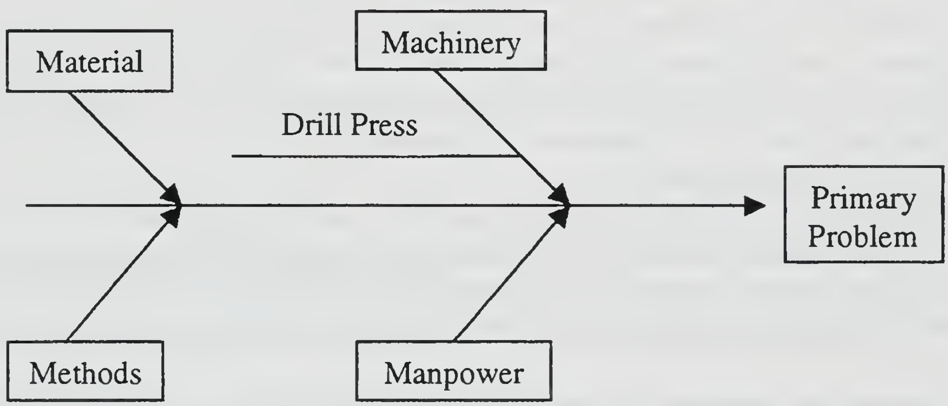


Figure 4. Cause-and-Effect Diagram (Fish-bone Chart). From Ref. [24].

The last quality management tool discussed in this section is SPC. It is a process used primarily to reduce variability and can be used to monitor processes and standards, make measurements, and take corrective action as a product or service is being produced. Samples of a process are examined and, if within acceptable limits, the process is permitted to continue. If the samples fall outside a specified range, the process may be stopped. The cause of the problem is identified and fixed. Control charts are graphic

representations used for SPC (see Fig. 5). These charts provide data over time that show upper and lower control limits for a process that is being measured and controlled. [24]

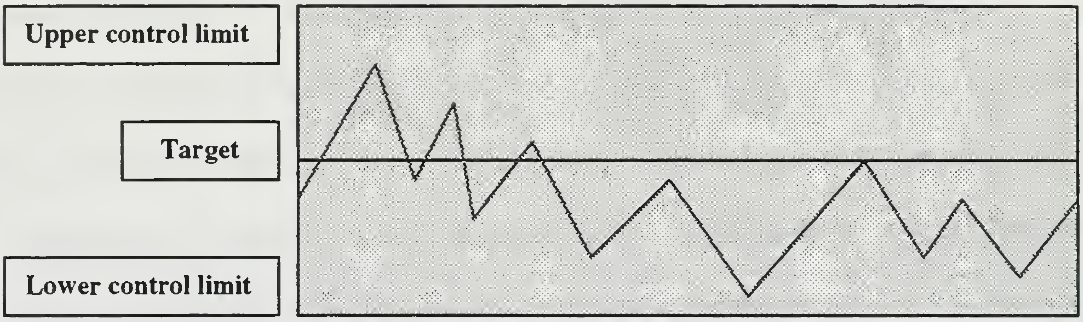


Figure 5. Control Chart for Statistical Process Control. From Ref. [24].

If the samples fall within the upper and lower control limits, the process is said to be in control. But if a discernible pattern develops, as depicted above in Figure 5 where the process consistently falls below the target, the process may be considered out of control or out of adjustment. [24]

A disadvantage of using SPC is that it only reflects the current process baseline. If the process must be rebaselined, the SPC parameters used to monitor the process must also be rebaselined to reflect the new process operating parameters. For example, if a more efficient component in a piece of equipment used in a particular process is installed, it may alter the operating characteristics of the equipment. Such is the case when more efficient modules like the high-pressure turbine are introduced into an aircraft engine. Without this rebaselining, managers may falsely suspect the process is out of limits. [24]

The organization may choose to use one or many of the these statistical techniques but without the proper training in the use of these techniques, the activity may derive little benefit from their use. An organization should select the ones that best suit the QMS it is

using and facilitates the conducting of its audits. Carefully selected quality management tools can enhance the effectiveness of an organization's QM audit program.

E. QUALITY MANAGEMENT AUDITS

Almost as soon as a QMS is implemented, it starts to become obsolete because an organization's operating restrictions, such as legal and resource constraints, and the needs of its customers are continually changing [6, p 53]. QMSs without a built-in, ongoing continuous improvement function become ineffective and inefficient when left to operate on their own [6, p 49]. Therefore, an effective audit process incorporates a built-in, ongoing continuous improvement function that supports and monitors a QMS. There are two basic types of QMS audits: internal (self) audits and external audits. Internal audits are periodically conducted by the organization to measure its own compliance and to identify improvement opportunities. External audits are normally conducted annually by external organizations to measure compliance to specific quality standards such as ISO 9000.

Clause 4.17 of ISO 9001 (see Appendix B) requires an organization to have documented procedures for conducting internal audits that are part of a management review process. Each of the 20 elements of ISO 9001 must be audited internally at least annually, but audit frequency can be increased based on past audit results. Past audits results may reveal that some processes are not consistently effective. When ineffective processes exist, the audit process provides an avenue for recommending changes to improve the deficient processes. Audits should be conducted to ensure that the

procedures that are used to run an organization are followed. If audits show that a procedure is not needed, the procedure should be eliminated. [25]

The internal audit process requires that several types of audits be performed. Each of these internal audits generally takes two (2) to three (3) hours. These include employee and supervisory self-assessments, internal staff audits, executive audits, and third party audits. This requirement addresses the fact that no one is in a better position to know whether the job is being done correctly than the employee who is doing the job. The next person best prepared to evaluate a department's output is not quality assurance, but the department manager. [25]

In most of the ISO 9000 activities visited during this research, ISO 9000 increased the number of internal and external audits and inspections. The exact number of additional audits that must be performed varies from organization to organization depending on the level of effectiveness of the existing QMS in identifying deficient processes, the degree to which processes are already documented, the willingness of employees to participate in the ISO 9000 auditing process, and the size of the activity.

The number of audits increases because an organization's existing QMS is generally not effective at identifying deficient processes. The existing QMS tends to focus on identifying non-conformities in the end product or service. Therefore, when the ISO 9000 audit process begins, there is a plethora of deficient processes that must be identified, carefully scrutinized for cause, and changed. Personnel at these activities generally agree; however, that ISO 9000 auditors examine process effectiveness and efficiency of the process rather than the quality of the end-product. The external auditors

look for objective evidence to prove that an organization is actually performing the activities it claims it can perform. [25]

According to Boeing employees working on the T-45TS at Kingsville Texas, AMMT and ISO 9000 audits are quite different [24]. AMMT auditors focus on requirements within the NAMP while ISO 9000 auditors focus on identifying process improvements. For example, AMMT auditors would conduct an in-process audit of a hydraulic contamination sampling procedure to ensure the technician is conducting the sampling procedure in accordance with the NAMP and other applicable instructions. Process deficiencies can be masked during these audits [2]. An ISO 9000 auditor, on the other hand, would audit the entire hydraulic contamination sampling process including the discrepancy feedback process to ensure that it is documented, that employees can easily understand the process, and that the process they use for correcting deficiencies is actually what is documented. S/he would identify systemic problems within an organization's processes. With an effective ISO 9000 QMS audit program in place, the T-45TS managers believe that many NAMP specific requirements can be eliminated because of the efficiencies realized by using ISO 9000 auditing procedures. [33]

Although a full discussion of the impact of the ISO 9000 QMS on cannibalization is beyond the scope of this thesis, the process of cannibalizing aircraft or aeronautical equipment parts is another illustration of the difference between ISO 9000 and AMMT audits. (Cannibalization is the robbing of parts from an aircraft, or aeronautical equipment, that is down for maintenance and cannot be brought to full mission capability in the near term to put into another aircraft that is down for maintenance and can be

brought to full mission capability in the near-term.) Discrepancies in the cannibalization process at organization maintenance activities are not readily apparent to AMMT auditors. AMMT auditors would check Maintenance Action Forms (see Chapter IV) to determine whether the activity's history of maintenance shows that cannibalization of aircraft parts is properly documented. If the activity's history on cannibalization actions is incomplete due to omissions in whole cannibalization actions within the history record, an AMMT auditor would not likely find the discrepancy because s/he is only checking the history that is available. An ISO 9000 auditor would audit the entire cannibalization process to ensure the activity has a well-documented cannibalization process, that employees can easily understand the process, and that the process they use for correcting deficiencies is actually what is utilized. [33]

F. IMPLEMENTATION OF QUALITY MANAGEMENT SYSTEMS

Implementing an improved QMS provides an opportunity to enhance effectiveness of business processes. It is a chance to get away from the adage "this is the way we have been doing it for years." One of the primary advantages of upgrading the QMS is to challenge the current system, eliminates poor and ineffective QM practices, and create an improved system that incorporates new and better practices and provides more value to the organization. [6]

The new QMS will have different characteristics from the QMSs used only a few years ago. For example, it will have employee empowerment and sense of process ownership, more effective SPC methods, and stronger employee "buy-in" in ensuring the

new QMS is successful and continually improved over time. It must be oriented to an environment that is continuously changing, where the workforce is driven by information technology, and much of the management control and direction is scaled back. The new QMS must be proactive and based primarily on preventive measures rather than reactive, corrective measures [6]. A proactive QMS based on preventative measures allows maintenance measures to schedule maintenance actions rather than react to maintenance requirements. When Officers and Chiefs are able to plan, maintenance can be accomplished more efficiently. Because this new QMS is likely to be radically different from the one previously used by an organization, the method with which it is implemented must be carefully chosen.

Several implementation methods are readily available from which an organization can choose. For example, imposed or informed implementation methods, implementation methods that focus on common risk areas such as sponsor commitment and target response (e.g., resistance to change), or the OCM plans discussed in Chapter II, may be used. Utilizing an informed (involved) implementation method for implementing the ISO 9000 QMS is preferred. Informed implementation involves those who will be impacted by the changes early on and throughout the implementation process. This leads to "buy-in," commitment to change, and ownership of processes. [4]

Activities normally take characteristics from several different implementation methods to best fit their organizational requirements. The most critical element for the success of an improved QMS is the implementation process. An effective QMS is only as good as the implementation method used and effort committed to making it work.

Frequently, it is assumed that once the QMS is in place, the job is complete. On the contrary, these systems must be nurtured, maintained, practiced, and improved upon to become a part of the culture and, henceforth, provide the organization with enhanced productivity, continuously improving maintenance practices, an improved safety record, increased morale, and improved products or services.

Implementation is usually broken into manageable portions. For example, the Naval Aviation Depot (NADEP) Cherry Point ISO 9000 implementation is being accomplished in a three-phase approach. During each phase, existing procedures for document and data control, control of customer supplied products, calibrated equipment recall, internal quality audits, training/qualification requirements identification, hazardous material life extension, tool procurement and stocking, and corrective action reports are improved. Additionally, new procedures for management review of operational processes, QMS standardization, control of non-conforming products, and material handling and storage are implemented. Phase one includes preparation and auditing for the ISO 9000 registration of NADEP Cherry Point's NEAC. The NEAC is a small engineering, manufacturing, and maintenance facility that performs rework and coating processes on the stators (vanes) and airfoils (blades) for compressor and turbine sections of gas turbine engines. It was started in August 1996 and completed in March 1997. Phase two includes preparation and auditing for the ISO 9000 registration of a group of small departments within NADEP Cherry Point: the Calibration and Materials Laboratories, Regulated Commodities, and Production Support Engineering. It was started in February 1998 and completed in February 1999. Phase three includes the

preparation and auditing of the rest of NADEP Cherry Point. It was started in August 1998 and will be complete by the end of 1999. The ISO 9000 QMS is being implemented sequentially in each separate division of NADEP Cherry Point. [2]

The NEAC was scheduled to close by early 1996 because it was losing up to $1.7 million annually by 1995 due to inefficiencies such as excessive turn-around times, approximately 100 days on average more than necessary, of its customers' components. Because of ISO 9000, the NEAC made a dramatic turnaround, is now sought out by civilian companies for its expertise and capabilities, and is now considered a cost-effective center rather than a cost center [2]. Not all activities experience this type of revelation with ISO 9000 implementation. Most companies that are not able to capitalize on ISO 9000 fail to do so because they were not willing to put in the time and effort required for implementation of the ISO 9000 QMS.

The time, cost, and efforts needed to implement ISO 9000 are difficult to quantify because they vary from organization to organization depending on size of the activity and the current condition of the existing QMS. Generally, however, it takes approximately two years to implement ISO 9000 and "all hands" must be involved in the process [25]. While the cost of becoming ISO 9000 registered varies from organization to organization, as much as 30 to 40 percent, it is generally between $20, 000 and $30, 000 [3]. [2]

Viewing this $20, 000 to $30, 000 as the cost of implementing ISO 9000; however, is misleading for three reasons. First, organizations often incur additional costs when they implement ISO 9000. These costs result from conclusions that an ISO 9000 registrar or the organization itself draws about how the organization can improve its

processes. For example, an ISO 9000 audit, either external or internal, may reveal that an organization could improve the efficiency of its inventory management process by incorporating an Automatic Storage and Retrieval System. Second, the costs resulting from ISO 9000 registration and process improvements are often balanced out by the savings that result from having more efficient processes [3]. Third, the process changes that are brought about by ISO 9000 are changes that organizations generally want to make anyway. These changes improve the quality of the product or service being provided. It is therefore difficult to differentiate these costs between: (1) the cost of becoming ISO 9000 registered and maintaining that registration or (2) the cost of doing business. [25]

The cost of not becoming ISO 9000 registered is that an organization's QMS stagnates. It fails to bring about the continuous improvement in a production or maintenance process that is needed for an organization to be responsive to customer needs and to make the customer confident that the product or service being offered has quality build in. Although it is difficult to quantify this cost in an exact dollar amount because the amount varies from organization to organization, it could potentially be very high. If an organization fails to meet a customer's needs or to assure the customer that the organization is offering a quality product or service, that customer will take his/her business elsewhere. As the organization loses more and more customers, it may eventually be forced out of business.

There are numerous ways to go about implementing a new QMS. The authors recommend the following proven approach formulated by a renowned quality expert; Dr. H. James Harrington [6]. His approach utilizes a six-step procedure—assessment,

planning, upgrading (or redesigning), implementation, auditing, and continuous improvement. Of all the QMS implementation methods available, this procedure is the most relevant to squadrons. The steps in this procedure are:

1. Assessment- Determine whether to upgrade the existing QMS. Determine the impact of upgrading. Prepare a rough time schedule for developing and implementing the appropriate procedures and supporting documentation.

2. Planning- Form a quality team composed of experienced quality management personnel. Define process owners and block diagram the major quality processes. Develop training plans for the QMS. Prepare a change management plan. This plan must address how the organizational configuration should be modified to produce the culture/paradigm needed to ensure the ISO 9000 QMS is effectively implemented. It must also identify who will perform the internal audits, develop a timeline for completing the audits, and assign responsibilities for conducting the audits. Furthermore, the plan should detail how continuous improvement can be achieved for the organization.

3. Upgrading- Prepare flowcharts of the assigned processes. Compare the present process to ISO 9000 standards and identify discrepancies. Correct discrepancies and include suggested improvements. Document the assigned processes.

4. Implementation- Address the organizational culture throughout the implementation process. Ensure documentation is in line with the culture of the organization. Roll out the new documented processes as they are completed rather than in one massive change. Evaluate and correct deficient processes. Conduct internal audits. Measure the performance level of the new processes. Analyze the total QMS.

5. Auditing- Establish and maintain an employee and management self-assessment process. Establish and maintain an internal and executive audit process. Establish external audit relationships to measure compliance to imposed QMS requirements such as ISO 9000.

6. Continuous Improvement- Assess the organization's personality. Set performance improvement goals. Define desired behavior and habit patterns. Develop improvement plans. Implement the improvement plan. [6]

In addition, the intrinsic dangers of Naval aviation require a need to quickly identify a discrepancy or improvement opportunity, evaluate its impact, and quickly change the documentation or explain to the employee why the documentation will not be changed. These dangers include working around the flight line or the aircraft carrier flight deck during high-tempo operations and flying in combat/military training scenarios. Because of this, an effective change-evaluation and/or problem-solving process must be in place to support the implementation process. [6]

G. CHAPTER SUMMARY

This chapter introduced the reader to the NAMP and ISO 9000 QMSs and discussed QM tools and QMS implementation. NAMP QM policies and procedures, including auditing and training, were discussed. ISO 9000 QM policies and procedures were also discussed. Then, it described the basic tools and training used to build an effective QMS. Finally, the QMS implementation section highlighted the steps needed to implement an effective QMS.

The next chapter discusses process maps as they relate to the NAMP and ISO 9000 QMSs. Methodology for developing process maps for the NAMP and ISO 9000 is presented. It includes a general hierarchical structure of processes and a documentation structure. The advantages and disadvantages of each process map are then described.

IV. PROCESS MAPS UNDER NAVAL AVIATION MAINTENANCE PROGRAM AND INTERNATIONAL STANDARDS ORGANIZATION 9000

A. INTRODUCTION

The keys to having an effective and ever-improving QMS are: (1) the ongoing involvement of squadron COs and MOs, (2) proactive process management and control, (3) the support of a basic infrastructure, and (4) continual system improvement. The QMS is made up of processes including QM documentation, QM training, QC, QA, and SPC, and defines how the organization manages quality in the products or services it produces. [6]

The focus of this chapter is to identify the primary processes that make up the QMSs in the NAMP and ISO 9000 QMS and then formulate process map development for these processes as they pertain to this research. This chapter also discusses the advantages and disadvantages of each of the primary process maps.

B. MAINTENANCE PROCESS MAP FOR NAVAL AVIATION MAINTENANCE PROGRAM

The Naval aviation organizational maintenance activity process flow map is depicted in Figure 6 below. Unlike the ISO 9000 standards, the NAMP does not describe a general interrelated process flow per se that can be applied to maintenance procedures. Instead, the NAMP provides the basis for establishing standard organizations, procedures, and responsibilities for the accomplishment of all maintenance on Naval aircraft, associated material, and equipment [5, Vol. I, p 7-1]. Figure 6 depicts a general

maintenance process flow that can be rationally extracted based on excerpts throughout the NAMP. It consists of: (1) maintenance types, (2) maintenance functions, and (3) NAMPSOP or Non-NAMPSOP programs.

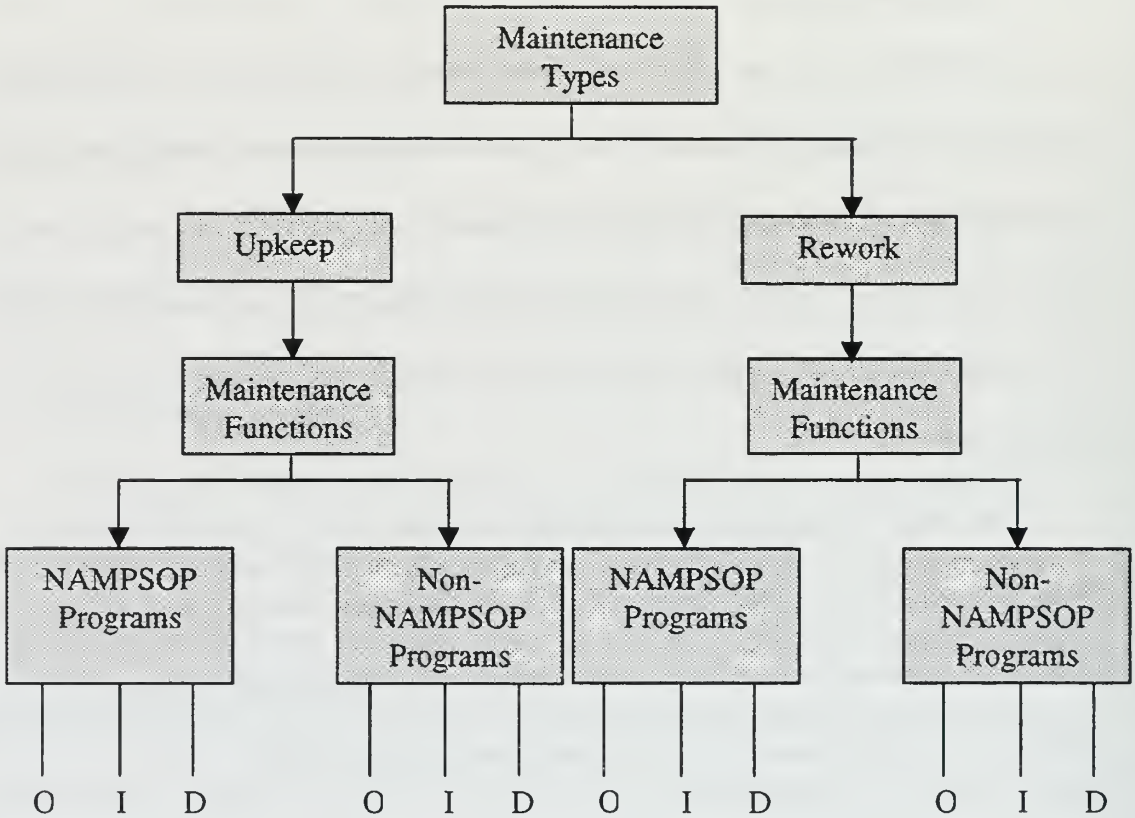


Figure 6. Naval Aviation Maintenance Program Process Map. From Ref. [5].

First, maintenance types come in two forms, upkeep and rework. Upkeep and rework are performed within the Naval establishment without distinction as to the level of maintenance [5, Vol. I, p 7-3]. The maintenance type at the organizational maintenance level is upkeep maintenance. Upkeep is the preventative, restorative, or additive work that is performed on aircraft or aviation-related equipment [5, Vol. I, C -59]. It is normally performed by military activities assigned aircraft and aviation-related equipment or the responsibility of providing direct support to such activities [5, Vol. I, C -33]. The

other type of maintenance, rework, is performed at industrial type activities assigned the mission, task, or functional responsibilities of providing maintenance program support. Rework is the restorative or additive work performed on aircraft or aviation-related equipment and is performed on either operating or non-operating aircraft or equipment [5, Vol. I, C-33].

Next, the NAMP assigns individual maintenance functions to a maintenance level. Maintenance functions are the separate operations that make up a maintenance action of aircraft maintenance work and are divided among maintenance levels. Maintenance levels are the increments of which all maintenance activities (i.e., maintenance organizations) are composed and allow common standards to be applied to the different aircraft types [5, Vol. I, C -29]. The maintenance function may be assigned to the organizational (O), organizational and intermediate (I), or intermediate levels of maintenance. In addition, NADEP (D) can perform any of the maintenance functions. The NAMP identifies the maintenance level for the organizational and intermediate levels so that an activity can identify those tasks related to a particular maintenance function that that activity is required to perform [5, Vol. I, p 7-3]. For example, Machine Operations is a maintenance function comprised of tasks that include drilling, cutting, riveting, filing, milling, pressing, and swaging. The organizational and intermediate levels of maintenance can perform drilling, cutting, riveting, and filing whereas metal and machine work such as milling, pressing, or swaging is performed at the intermediate level of maintenance. A detailed listing of maintenance functions are provided in Volume I of the NAMP. [5, Vol. I, Fig. 7-1]

Finally, maintenance functions are further broken into NAMPSOP or Non-NAMPSOP maintenance programs. The NAMPSOPs, as previously described in Chapter II, establish policy, responsibilities, and requirements for implementing programs within aviation maintenance activities. NAMPSOPs provide procedures for maintenance programs and processes in sufficient detail so that additional instructions written below the Naval Air Systems Command level are not required (with the exception of local command procedures) [5, Vol. I, p C-38]. Non-NAMPSOP maintenance programs are intended to be implemented using Volume I of the NAMP and specific program-related technical manuals that are identified within the program text [5 Vol. I, p 10-1]. For example, the Nondestructive Inspection (NDI) Program is governed by technical publications that pertain to NDI procedures and qualification requirements; NAVAIR technical manual number 01-1A-16, NAVAIRINST 13070.1, and other applicable Technical Directives and publications [5, Vol. I, p 10-2]. The process map for ISO 9000 must now be described, so that, it can be compared to the maintenance process map under the NAMP.

C. PROCESS MAP FOR INTERNATIONAL STANDARDS ORGANIZATION 9000

Processes form the building blocks for ISO 9000 QMSs and process owners play a critical role in making the overall processes flow smoothly. The term process owner is used here but can easily be substituted with process manager, process leader, or process

sponsor depending on the activity's preference or accepted use of job titles. The process owner has the overall responsibility for ensuring the process functions smoothly.

With the ISO 9000 QMS in place, the organization can stop looking at the business as many divisional functions and start looking at it as many interrelated processes unique to the activity as a whole. The ISO 9000 series, ISO 9000, 9001, 9002, etc., helps personnel understand the process view of their organization. This view is the understanding of the network of parallel and interrelated processes that form an organization's operations. This network can be modeled as a concentric, hierarchical structure of processes that are comprised of QM policies, procedures, and control techniques. [6]

The process network is divided into five elements. Each subsequent element is a product or a part of the previous tier. Referring to Figure 7 below, the five elements are: (1) macro-processes, (2) processes, (3) activities, and (4) tasks, and (5) the organization's mission and objectives. The organization's mission and objectives are not formally incorporated in the ISO 9000 standards but are included in this thesis to help Airmen and POs understand the elements within the process structure. [6]

The first ISO 9000 process network element is macro-processes. These are a group of interrelated processes required to meet an organization's overall objectives. The organization's quality manual is at this level. This document defines what needs to be done. The quality manual is the key document around which the QMS is built. Any other manuals within this element should explain what needs to be done and why it should be done, not how it is done.

The second element consists of processes. It provides a logical, related, sequential set of work flows. The process can be further divided into sub-processes if it proves too complex as a single process. The process owner is normally assigned at this level but may be assigned to any level commensurate with the complexity of the element or portion within. For example, tool control is one type of process that must be performed to maintain aircraft and is characteristic of the type of processes that comprise the second element of the ISO 9000 process structure. The tool control process consists of the management of aircraft tools, the management of test equipment, and the management of support equipment such as ladders used in aircraft maintenance. Each of these areas of tool control are considered to be sub-processes.

The third element is comprised of process work activities. This includes all the functions that take place within the process. A work activity is usually documented in an instruction or set of work procedures.

Tasks are the fourth element and make up the work activities. They are documented in the third element's instructions or work procedures. Tasks are detailed steps taken to perform an activity. [6]

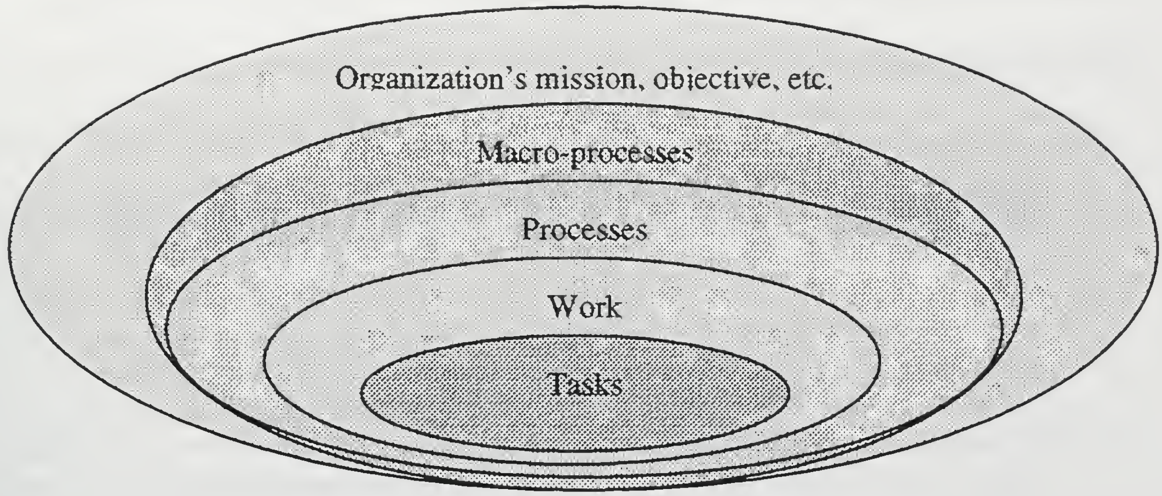


Figure 7. Typical International Standards Organization 9000 Process Hierarchy Breakdown.

Each of the elements listed in Figure 7 may be combined or broken down further depending on the organization's requirements. It is important that each inner-level element be supportive of the outer level elements.

The NAMP and ISO 9000 process maps described above are supported by documentation systems that can be described in process maps of their own.

D. DOCUMENTATION PROCESS MAP UNDER NAVAL AVIATION MAINTENANCE PROGRAM

Figure 8 depicts each of the departments that comprise a squadron. The documentation process flow described in this section is for the maintenance discrepancy process flow within the maintenance department. Although a strong, effective, and efficient QMS embraces all the departments within the squadron, only the maintenance department's documentation process is directly concerned with aircraft maintenance discrepancy repair actions. The processes within the other squadron departments and the

impact of the ISO 9000 QMS upon those other departmental processes is beyond the scope of this thesis.

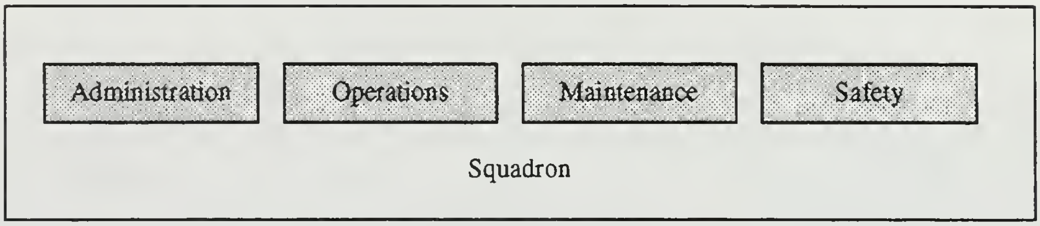


Figure 8. Typical Departmental Composition of a Squadron. From Ref. [5].

Figure 9 depicts the maintenance documentation process map under the NAMP. More specifically, it lists those maintenance documentation procedures unique to the organizational level maintenance work centers. The example provided below describes the NAMP's process flow for the Visual Information Display System/Maintenance Action Form (VIDS/MAF). Figure 9 is depicted in such a way that it is applicable to either VIDS/MAF or NALCOMIS.

VIDS/MAFs are multi-purpose documents used in MDS, as defined in Chapter II [5, Vol. I, p C-60]. NALCOMIS is a computer-based, semi-automated Management Information System (MIS) that allows aviation maintenance personnel to record flight data and maintenance actions [5, Vol. I, p C-37]. It also allows Officers and Chiefs to access data quickly to obtain timely and accurate aircraft and equipment maintenance status, maintenance requirements, and other decision support information [5, Vol. I, p C-37]. The VIDS/MAF MDS paper-intensive system is being replaced with the paperless, electronic NALCOMIS system at the Naval aviation organizational level maintenance activities.

Appendix D provides an example of a MAF documented for a work request turn-in. It is a work request from the organizational level of maintenance to the intermediate level of maintenance for a check and test procedure that is beyond the capability of the organizational level of maintenance. Documentation details can be found in Volume III of the NAMP and are beyond the scope of this thesis.

Referring to Figure 9, the Maintenance Control work center directed by the Maintenance Material Control Officer is the central authority that coordinates all job tasking within the maintenance process and must be in control of maintenance at all times [5, Vol. I, p 15-3]. Maintenance Control schedules, sets work priorities, and assigns all jobs to their respective work centers, and estimates the time needed to complete each job.

Scheduling jobs is complex and requires Maintenance Control to be continuously vigilant to ensure that aircraft operational availability can be maximized. Job priorities are normally set based on an estimated time to repair, ability to obtain parts, and expert input from the technicians in the work centers. The primary objective is to have the aircraft repaired and ready to fly again when needed. [5]

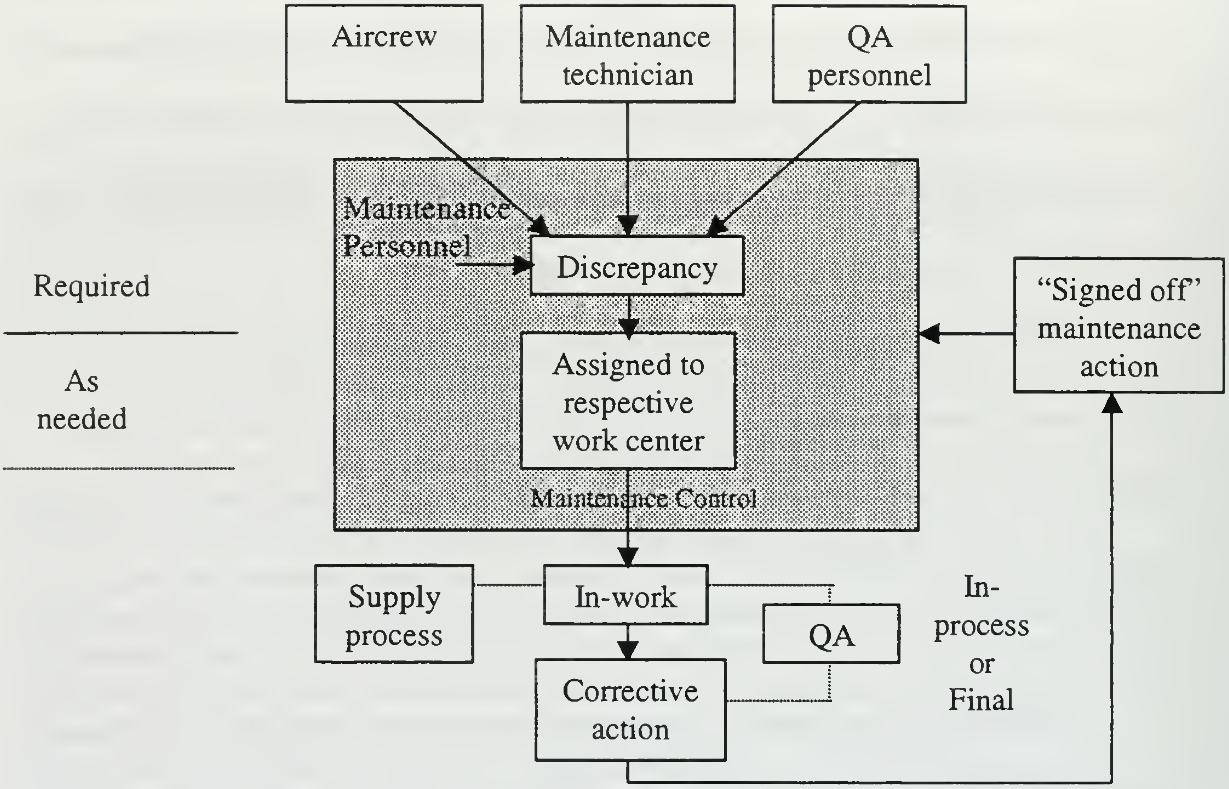


Figure 9. Naval Aviation Maintenance Program Documentation Process Flow for a Maintenance Action. From Ref. [5].

The time to effect a repair and the types of corrective actions can be considerably different from one job to another even when similar discrepancies occur. This variation in time to complete maintenance actions is caused by a number of factors including interruption of maintenance from other operational commitments, lack of availability of the proper support equipment, and lack of the available support facilities such as compressed air and electrical outlets. Also, troubleshooting techniques used and the technician's skill level introduce additional variation into the process. For example, several different types of multi-purpose test equipment that can be used for the same maintenance action may be available because of the large variety of maintenance

functions assigned to each of the work centers. As a result, the use of one particular piece of this test equipment over another that could be used for the same maintenance function may introduce additional variability into the time to complete maintenance actions in organizational maintenance. [5]

Referring again to Figure 9, maintenance discrepancies are written on MAFs or entered into NALCOMIS on each aircraft that has a maintenance discrepancy between flights. These discrepancies are reported and written up by the aircrew, maintenance technicians, QM POs, or Maintenance Control. [5]

Maintenance Control assigns the job to the work center responsible for that maintenance function. The maintenance department is divided into work centers that perform specific tasks such as electrical, electronic, airframes, power plant, or ordnance functions. When Maintenance Control wants a particular maintenance action to be completed, it directs the work center to go into an "in-work" status, and the work center begins working to correct the discrepancy. [5]

Safety-of-flight related discrepancies require an inspection from a representative of the QA division before the task can be signed off. The QA representative performs both in-process and final inspection. In-process inspections are conducted when satisfactory task performance cannot be determined after completion of the task. These inspections, when required, include witnessing application of torque, functional testing, adjusting, assembly, servicing, and installation. Final inspections are performed following the completion of a task or series of tasks. They are used to ensure a maintenance action is complete. Examples include the inspection of aircraft panels that

have required corrosion treatment and painting or inspections to ensure the flight controls in the cockpit are not binding after cockpit panels have been removed and reinstalled. [5, Vol. I, p 14-5]

In addition, aircraft parts or equipment may be required during the maintenance action. They are acquired via the supply process, a process that will not be explained in this thesis as it is beyond the scope of this research. Finally, the work center technician, inspector, and supervisor document the corrective action, electronically "sign off" the discrepancy form in NALCOMIS, or physically sign it off if it is on a MAF, and forward it back to Maintenance Control to indicate completion of the maintenance action. Maintenance Control then returns the aircraft back to flight status. [5]

The innumerable types of corrective actions that are produced from this process transform maintenance resources into a good or service depending on how aircraft maintenance is viewed. The resources are man-hours, parts, and materials. The good or service is an aircraft that is ready to fly again and has been restored to a state of readiness to complete missions for which the aircraft is designed. [5]

The documentation process map for the ISO 9000 QMS must be described to compare it with the documentation process map for the NAMP.

E. DOCUMENTATION PROCESS MAPS UNDER INTERNATIONAL STANDARDS ORGANIZATION 9000

The documentation process map for the ISO 9000 QMS can be thought of as a pyramid. Its purpose is to help an organization describe the operational activities and

functions it performs to produce a product or service. This allows ISO 9000 auditors to assess whether an organization does what the quality manual actually states. The adage that is typically used to describe this purpose is, "Say what you do, do what you say, and prove it." [7] The ISO 9000 documentation structure is built on watching personnel perform their job and then auditing processes documents to ensure they state exactly what personnel do [7]. Each level of the pyramid builds upon the preceding level, a bottom-up approach. Referring to Figure 10 below, the apex of the pyramid consists of the quality manual. The second level consists of the quality procedures. The third level consists of the quality work instructions. The fourth and final level is composed of records and forms. [34]

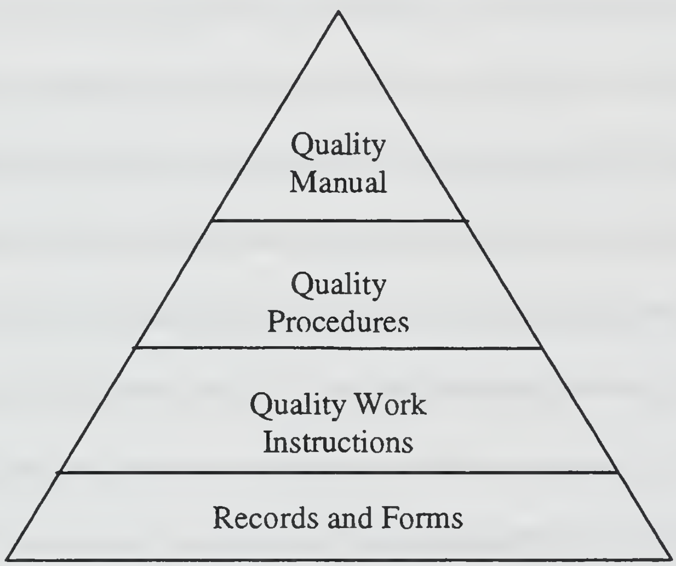


Figure 10. International Standards Organization 9000 Documentation System Structure. From Ref. [34].

The first level, the quality manual, is a document stating the quality policies and describes the quality system of an organization. The quality manual presents an

organization's structure and key roles and describes how the organization's QMS will satisfy each of the ISO 9000 clauses listed in Appendix B as they apply to the organization. It also describes how the organization will satisfy the sub-clauses of each of the 20 main clauses listed in Appendix B. Examples of quality manuals from Lockheed-Martin, NADEP Cherry Point, Boeing, and United Airlines were evaluated for this thesis. All are too long for inclusion as an appendix to this thesis. [34]

Nevertheless, five generalizations can be discussed about the quality manuals researched for this thesis. First, even though the ISO 9000 QMS requires an organization to have a quality manual, ISO 9000 standards do not dictate the format of the quality manual. It only requires that an organization describe how its policies and procedures will satisfy the ISO 9000 clauses. This allows the activity to customize its manual to meet the organization's specific customer requirements. Second, not every element of the ISO 9000 standards will be applicable to every organization. Organizations sometimes do not have operating procedures and processes that may pertain to specific clauses. When this is the case, the quality manual must simply state that a particular clause is not applicable to the organization and explain why. Third, each of the clauses is tailored specifically to the operating procedures and policies used by the organization. Fourth, the quality manual helps an organization identify areas within its procedures and policies which are insufficiently defined to: (1) allow the organization to properly manage quality and (2) to help an organization's customers assess whether the organization's processes and policies are efficacious enough to produce a product or service that satisfies the customer. Fifth, the quality manual can be built around an organization's existing QM

policies and procedures. The ISO 9000 QMS does not invalidate these existing QM policies and procedures [7]. [34]

The second level, quality procedures, details the steps required to carry out the quality policies given in the quality manual. They give the steps and assign responsibility to who does what, when, and what documentation is required [34, p 10]. For example, the book of procedures for the QM department should be called the Quality Procedures Manual and should contain the procedural documents for the QM department [35, p 49].

The third level, quality work instructions, are intrinsically linked to the quality procedures that make up second level of the ISO 9000 documentation pyramid. They are comprised of descriptions on how to carry out specific steps in these procedures. Work instructions detail methods and guidelines addressing how to perform the task. [34]

The fourth level consists of records and forms. They contain evidence and control mechanisms to show compliance with and results of the operating procedures and policies established by an organization [34, p 10]. Records and forms provide the actual data recorded to show that a specific requirement has been met or an activity has been completed correctly. The format, who fills out the documents, how they are processed, and how they are stored are defined in level two and three documents. [5]

Each of the level two, three, and four documents might be referenced in any or all of the documents from the levels above it [34]. For example, Appendix E contains an example of an SOP from the T-45TS Program that incorporates levels two through four of the ISO 9000 documentation pyramid. The changes that must be made to the NAMP based on the ISO 9000 format seen in the T-45TS SOP are discussed in Chapter VI.

The following is an example of the relationships between the four different levels of documentation for Control of Inspection, Measuring, and Test Equipment:

Standard	ISO 9001 Clause 4.11
Level 1	Quality Manual Section 11
Level 2	Engine Acceptance Control Procedure 11.1
Level 3	Quality Work Instruction 11.1.1 that selects the appropriate inspection, measuring, and test equipment needed and describes the measurements to be made and the necessary accuracy and tolerances.
Level 4	Quality Form 11.1.1.1 is the record of the maintenance action. [34]

The documents are numbered sequentially to make the flow of information easy to follow from the quality manual to the procedures to the work instructions to the storage of the forms for completed maintenance actions. Section 11 of the quality manual covers the general policy for Control of Inspection, Measuring, and Test Equipment. The quality procedure section 11.1 provides the steps that company personnel will follow when an inspection or measurement is required. Work instruction 11.1.1 details how to accomplish the process by indicating the appropriate inspection, measuring, and test equipment needed and describing the measurements to be made and the necessary accuracy and tolerances. The last and final level, level 4, is the record indicating accomplishment of the maintenance action. [34]

ISO 9000 auditors require an organization to build process flowchart. This flowchart is constructed as a matrix that is divided into the levels in the ISO 9000 documentation system and that shows the flow of processes between functional areas and

the subordination of requirements from one the authority level to the next. This flowchart assists auditors to visually see the formal tenets of processes which in turn helps the auditors know what aspects of a process to focus on during and audit. The building of this flowchart will also involves the performance of a "gap" analysis to determine what processes, instructions, procedures, and policies are needed and why and how many of the processes are not currently formally established and need to be. Afterward, existing processes, instructions, procedures, and policies are refined as needed and others are added. Processes, instructions, procedures, and policies that are not needed are eliminated. Because of the number and complexity of the processes that may be examined in a "gap" analysis, the "gap" analysis may require the performance of several iterations. Finally, the flowchart is updated with each iteration of the "gap" analysis. [7]

Having described and depicted NAMP and ISO 9000 process flow and documentation flow, the advantages and disadvantages of each are discussed in the following sections.

F. ADVANTAGES OF EACH

The advantages and disadvantages of using the NAMP or ISO 9000 processes, including documentation processes, are listed in this section. First the advantages of the NAMP processes are:

1. The NAMP clearly defines responsibilities for standard organization and programs. This ensures that accountability can be assigned to a particular individual for accomplishing specific activities.

2. The NAMP establishes Maintenance Control as the central authority for all maintenance actions. This ensures that all maintenance actions are controlled and prioritized through a single source, minimizing confusion.

3. The NAMP and its NAMPSOPs standardize maintenance programs which reduces variability in maintenance processes. This is not far removed from the intent of the ISO 9000 documentation structure.

4. The NAMP promotes thorough record-keeping and efficient control of critical documents.

5. The NAMP requires documented training. All Airmen and POs are required to have individual training folders that document maintenance training.

Second, the advantages of the ISO 9000 processes are:

1. ISO 9000 is a philosophy of prevention rather than detection. This allows the maintenance manager to plan and control the work schedule rather than the other way around.

2. ISO 9000 requires continuous review of critical process points, corrective actions, and outcomes. As a result, people pay attention to the details [2]. This is one of its cornerstones.

3. ISO 9000 promotes consistent communication within the process, and among the activity, its suppliers, and customers. The activities are standardized from one ISO 9000 compliant activity to the next such that the suppliers and customers can expect the same reliable process every time.

4. ISO 9000 promotes thorough record-keeping and efficient control of critical documents to a level that is greater than the NAMP. Process documentation is much more stringent under ISO 9000 [2].

5. ISO 9000 promotes total quality awareness by all employees. The employees become the owners of the processes that make up the activity's QMS. In addition, the employees understand one another's processes since the entire organization is under the same QMS. Every person gets involved with the management of product or service quality [2]. [7]

6. ISO 9000 promotes a high level of management confidence. ISO 9000 standards were developed by quality experts from around the world, worked and reworked over many years, and are proven effective by hundreds of companies. ISO 9000 series requirements are universally accepted as good business practices. [6]

7. ISO 9000 requires documented training and SPC processes that must be proven during the audit process [25]. This helps organizations improve their QC and perform trend analysis. The results of trend analysis may lead to the uncovering of quality management problems and further QM education to eliminate these problems. [31]

8. ISO 9000 reduces workload variability that results from a reduction in the amount of rework that must be performed [2].

9. ISO 9000 forces managers to plan for future operational commitments by requiring the elimination of wasted or excess resources on-hand [2].

10. The ISO 9000 standards are non-prescriptive of specific QM techniques. Therefore, they work with the QMS organizations already have in place and can be applied to virtually any product or service made by any process anywhere in the world. Also, they allow maintenance personnel to determine what is the best way of performing a maintenance process. [33]

G. DISADVANTAGES OF EACH

This section lists the disadvantages of the NAMP and ISO 9000 standards processes. First, the NAMP disadvantages are:

1. The NAMP does not provide a set of interrelated process flows. It provides only the basics for establishing standard organizations, procedures, and responsibilities for the accomplishment of maintenance.

2. The NAMP does not group QM practices and policies in any particular section. Rather, it touches on QC elements sporadically throughout its contents. If the ISO 9000 QMS is adopted in Naval aviation organizational maintenance, the NAMP format would have to be adjusted to consolidate these practices and policies, as discussed in Chapter VI.

3. The NAMP states that NAMPSOPs are encompassing in that they require little additional instruction to comply with their contents. Conversely, NAMPSOPs typically refer Airmen and POs to other maintenance instructions and technical manuals. A process chart similar to those used in the ISO 9000 QMS is not included in the NAMPSOPs but should be. Process maps help maintenance technicians pictorially see the process flow for complying with maintenance processes.

4. The NAMP prescribes QM procedures with little input from Airmen and POs [33]. This top-down directive approach to the assignment of maintenance functions and responsibilities provides limited flexibility for improving NAMP programs and procedures[33]. It also does not allow for business practices that take advantage of new business technologies. [2]

5. Information on the amount of time to repair each discrepancy and the visibility of aircraft parts on order is difficult to obtain and varies from job to job. Having this information helps maintenance managers establish a schedule for accomplishing maintenance and determining priorities. Without this information, Officers and Chiefs cannot be as proactive in scheduling maintenance because they only know the approximate time required to complete maintenance actions.

6. The majority of maintenance actions are corrective rather than preventive. This inhibits the maintenance manager's ability to effectively schedule and plan aircraft maintenance. Officers and Chiefs are not tracking the ratio of unscheduled to scheduled maintenance. They are therefore unaware of the variability introduced into scheduling aircraft maintenance that a high ratio of unscheduled to scheduled maintenance causes.

7. The NAMP QMS is largely biased toward achieving QM through QC procedures, with little emphasis on QA procedures. QC ensures conformity specifications are met through inspection and test functions after a good or service has been produced. Finding an error in the product after the fact is too late. [2]

8. The NAMP does not promote involvement by all Airmen and POs. It is non-responsive to the changes that employees at the lowest levels in an organization would like to see [33]. The result is that the most fruitful source of ideas for process improvements, maintenance personnel at the lowest levels, is inhibited from making positive changes to the way QM is practiced in organizational maintenance activities. [2] It does not strongly describe the responsibility of squadron COs and MOs in squadrons to actively involve themselves in the building and support of the QMS within

their activities. Under the current NAMP QMS, Officers and Chiefs allow their commitment to support a given operational tempo to consume their attention to the detriment of improving the processes and QMSs of their organizations.

9. The NAMP is rigid in its capacity to be changed. It is difficult to bring about the changes that might result from continuous improvement thus inhibiting the ability of Airmen and POs to improve the effectiveness of the QMS within the NAMP. [33]

Second, ISO 9000 standards disadvantages are:

1. ISO 9000 standards do not guarantee a successful QMS because they do not solve human factor problems. ISO 9000 requires a level of discipline, and if Airmen and POs take shortcuts, then ISO 9000 breaks down. ISO 9000 compliant organizations can perform poorly if the employees do not have integrity. [2]

2. ISO 9000 focuses on the process used to produce a good or service and is not concerned with the good or service itself. It does not discriminate between outcomes [7]. For example, United Airlines is an ISO 9000 registered company, but it is currently rated 10 of 10 major airlines in terms of overall cycle time. This rating takes into account every action from the accomplishment of a particular repair action to the turn-around inspection of an aircraft as it is readied for the next flight to response to customer service request.

3. Under an ISO 9000 QMS, customers are the final driver of the actual quality of the product or service, not the ISO 9000 QMS or auditors [7]. The concept is that ISO 9000 provides standardization of processes and gives customers confidence that an organization does what it says it is doing. This does not necessarily mean that the organization's processes are the best in the business; only that they are documented and standardized. ISO 9000 standards are built on the underlying assumption that the economic market in which an organization does business will form a feedback mechanism for the level of quality in the organization's product or service [7]. The feedback materializes as decreased customer satisfaction with and/or lower demand for the product or service. It also signals to the organization whether the product or service it is producing is meeting the customer's needs. If the product or service is not satisfying the customer, the customer can take his/her business elsewhere. This

feedback mechanism is absent from squadrons. Although squadrons have customers such as aviators and others, these customers are captive and they are not clearly distinguishable. When these customers are dissatisfied with the quality of the product or service they are receiving, they may be able to bring about some change through coercion, negotiation, or other means. They cannot simply take their business to another organizational maintenance activity, however. The result of having captive customers is that the market feedback mechanism is significantly diluted. Also, customers at the organization maintenance level are not clearly defined. They have competing demands in which no prioritization is provided for these maintenance activities. The result is that these activities attempt to spread their resources thin in satisfying all its customers at once. For example, are the primary customers of a Naval aviation organizational maintenance activity the pilots assigned to these activities, the Carrier Air Wing Commander, the Type Wing Commander, the Type Commander, or another customer. The demands of this diverse group of customers can frequently be mutually exclusive.

4. Assigning responsibility to a particular task is difficult because of the overlapping of processes and tasks. This can create confusion when attempting to identify process owners.

5. Since the ISO 9000 QMS will identify processes that are deficient, it will probably require an organization to add to its existing documentation and audit systems. This might be viewed by Airmen and POs as Officers and Chiefs placing an additional burden into the workload of the organization. [33]

6. Because the ISO 9000 QMS has elements that are characteristic of a hybrid organizational configuration, it cannot be adopted in pieces [21].

7. The ISO 9000 QMS must be frequently audited to ensure it is bringing about continuous improvement. The number of audits that must be conducted in one year can be significant. This brings resistance from personnel. Although they recognize the benefits of performing the audits and believe the results of such audits are worth the effort, the may be whelmed by the amount of time given up annually to performing audit [7].

H. CHAPTER SUMMARY

A process map provides the user with a simplified, easy to use tool for accomplishing the activity's processes. This chapter has identified the primary processes

and process maps for both the NAMP and ISO 9000 standards as they pertain to this research. It also discussed the advantages and disadvantages of the NAMP and ISO 9000 standards and processes.

The next chapter describes what makes up a QM training program. Training policy, responsibilities, and requirements for implementing QM training are described as established by the NAMP and ISO 9000. Finally, disadvantages and advantages of each system are discussed.

V. TRAINING IN QUALITY MANAGEMENT PROCEDURES

A. INTRODUCTION

The ability to complete tasks and accomplish the activity's objectives and mission is a result of the synergistic knowledge and efforts of the employees within the activity. The employees' scope and depth of knowledge is directly correlated to the amount of training they receive. Therefore, the need for proper training is paramount for an activity to achieve its desired level of success.

Employees should receive both formal and informal training. Formal training consists of classroom training with an approved syllabus. Informal training consists of on-the-job (OJT) training, technical assistance hands-on training, passed-on experience, and any other learning activities that affect the employee's ability to perform tasks other than those learned in classroom training. [5]

This chapter focuses on identifying the NAMP and ISO 9000 training processes and those activities critical to their success. More specifically, NAMP training policy, responsibilities, and requirements for implementing training within aviation maintenance activities are discussed and ISO 9001 elements are discussed as they pertain to this research. Finally, advantages and disadvantages of the training processes associated with each QMS are discussed.

B. NAVAL AVIATION MAINTENANCE PROGRAM TRAINING

According to the NAMP, the Naval aviation maintenance training policy requires that program organization and management be coordinated to ensure minimized operating costs, personnel movement, training pipeline time, and special manning requirements. One method of accomplishing this is to standardize training to the maximum extent possible, consistent with operational requirements and capabilities. The maintenance training program should be designed to provide all Airmen and POs with the same level of training necessary to support existing, planned, and future weapons systems. Training is provided to all Department of the Navy personnel to operate, maintain, and support aircraft weapons systems, and related equipment. [5, Vol. I, p 20-1]

Multiple echelons are involved in training aviation Airmen and POs [5, Vol. I, p 20-1]. Figure 11 depicts the most common relationships in the NAMP training hierarchy that are inherent to training aviation maintenance personnel.

The CNO, under the direction of the Secretary of the Navy, has overall responsibility for the training of Naval personnel as mandated in the NAMP [5, Vol. I, p 3-1]. Activities under the direction of the CNO that accomplish the Navy's training objectives are discussed below. [5, Vol. I, p 20-1]

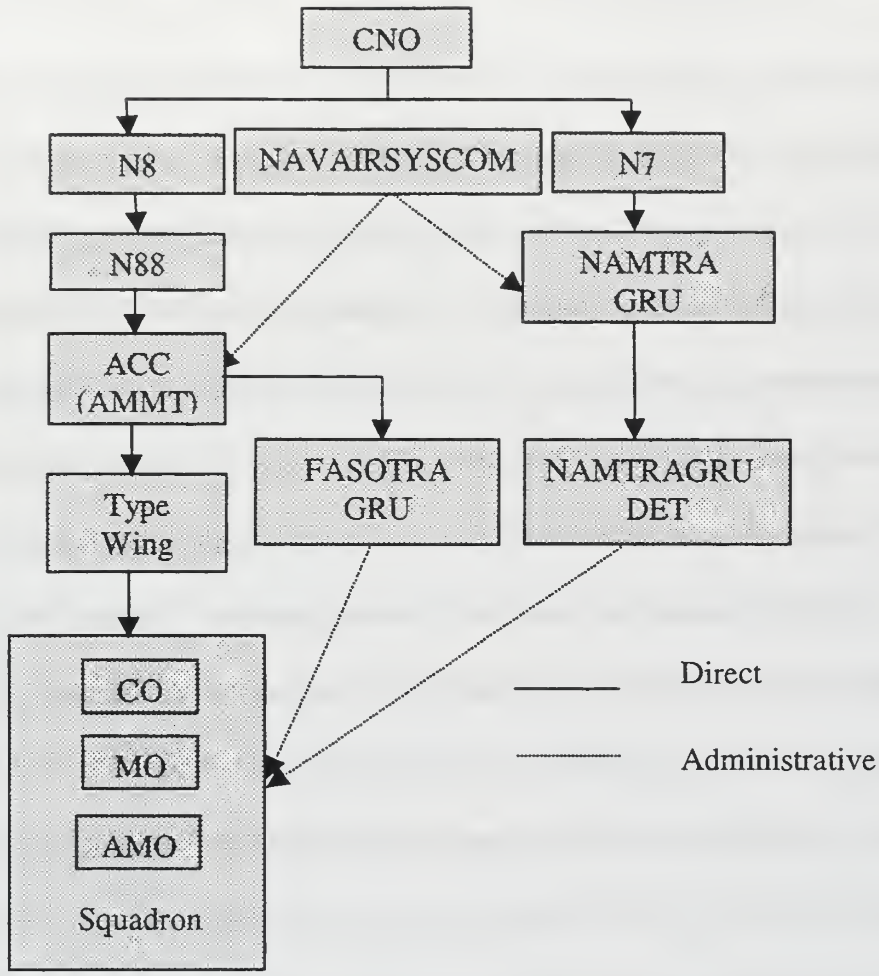


Figure 11. Naval Aviation Maintenance Program Training Hierarchy. From Ref. [5].

The Director, Air Warfare Division (N88), under the Deputy CNO (Resources, Warfare Requirements, and Assessments, N8) is responsible for the supervision and direction of aviation training which includes formal technical class "A" school training and the programming of aviation resource requirements such as training manpower and funding. Technical class "A" school training provides ratings (job classification) and is one way in which Airmen and POs receive a rating designation that they normally maintain throughout their navy career. [5, Vol. I, p 20-1]

The Director of Navy Training/Chief of Naval Education and Training (CNET, N7), develops overall policy, standards, and procedures for training, and in conjunction with N88, establishes procedures for validation and review of assigned training programs. These training programs include formal training and correspondence training. [5, Vol. I, p 20-2] The Naval Aviation Maintenance Training Group (NAMTRAGRU), under CNET, provides training in the operation, maintenance, and repair of aviation systems and associated equipment [5, Vol. I, p 20-5]. This is done through the NAMTRAGRU Detachments (NAMTRAGRUDET) located as tenants at major activity locations.

The Commander for Naval Air Systems Command (COMNAVAIRSYSCOM) initiates action for development, procurement, installation, maintenance, and repair of equipment in support of aviation training programs. In addition, COMNAVAIRSYSCOM plans, programs, and budgets for all training of logistics support items related to new acquisitions and major modifications, and provides recommendations to improve aviation maintenance training. [5, Vol. I, p 20-2] COMNAVAIRSYSCOM does this through a liaison relationship with the Aircraft Controlling Custodians (ACC) and NAMTRAGRU.

The ACC is responsible for managing and maintaining the AMMT. The AMMT's mission is to advise and assist activities by identifying maintenance program deficiencies, providing training, and assisting in performance improvement. This is accomplished primarily through the use of the CSEC checklist which is tailored to satisfy the auditing requirements of the AMMT. [5, Vol. I, p 4-3] In addition, the ACC directs the Fleet Aviation Specialized Operational Training Group (FASOTRAGRU) and

supervises quota control of all maintenance training courses provided by FASOTRAGRU. [5, Vol. I, p 20-3] FASOTRAGRU trains Airmen and POs in courses covering operational and tactical employment of specific equipment or systems and in maintenance administration and management [5, Vol. I, p 20-5].

Responsibilities specifically assigned at the organizational level of maintenance for training are provided as a NAMPSOP. Navy aircraft Type Wing activities exercise control of training over assigned squadrons and recommend training requirements to ensure optimum readiness of squadrons [5, Vol. I, p 5-1]. They develop training requirements standardized throughout squadrons employing the same or similar type aircraft. The squadron CO is responsible to the Type Wing Commander for the training within the squadron. In addition, the CO is responsible for the inspection and quality of material, and safety of Airmen and POs and equipment under their cognizance [5, Vol. I, p 11-1].

The CO assigns an officer to the billet of squadron MO normally for a minimum of one year. The MO manages the maintenance department and is responsible to the CO for the accomplishment of the department's mission [5, Vol I, p 11-6]. The MO designates the assistant maintenance officer (AMO) as the Maintenance Training Program manager who is then responsible for all areas of training for maintenance department personnel.

Examples of training areas typically coordinated by the AMO include ensuring that enough Airmen and POs are trained and licensed to operate the support equipment used in the squadron's daily operations, and ensuring Airmen and POs are properly

trained for the type of work they perform in the squadron. This training is normally accomplished through a mix of formal schools and informal OJT training. The AMO uses the NAMTRAGRUDET and FASOTRAGRU to accomplish the squadron's formal training requirements. In addition, the AMO uses CSEC information to aid in evaluating the maintenance department's performance and identifying specific areas that may require additional training. The AMO receives CSEC information from the QA division through audits they conduct using CSEC checklists. The work center supervisor ensures training is completed and documented in the individual's training record. [5]

The quality of training the employees receive should be visible through the efficiency and effectiveness of the activity. Also, according to employees at Boeing's T-45TS activity, this training must be closely coupled with practice and real-life application because its effectiveness becomes greatly diminished if not applied as soon as possible. [33]

The method for measuring the effectiveness of the training program and processes within the organizational level maintenance activity is through the audit process. The audit process provides some feedback about the training programs and processes but is limited because it only requires training to be documented. It does not describe how to train Airmen and POs to accomplish maintenance related activities or what training is available to maintenance personnel, it also does not address effectiveness and quality of training. In addition, the CSEC checklist is a "yes" or "no" in-compliance requirement that is highly variable from one QA representative to another. CSEC generates all checklists for audits, provides for collection of discrepancy data, and produces reports

that can show processes where maintenance training is weak. A QA representative may check "no" for a question such as "Are training jackets current and up to date?" if s/he determines that the work center's training is not meeting what the QA representative deems sufficient. The work center supervisors are responsible for taking corrective actions on all training discrepancies found during the audit. The QA division determines a future time to do a follow-up audit to ensure the discrepancies are corrected. The future time selected is normally one week but depends on the extent of the discrepancies. Regardless, the discrepancies are expected to be corrected prior to the following three (3) month audit.

The two types of audits conducted by the QA division are work center and special audits. Work center audits are conducted quarterly to evaluate overall quality of each work center's performance. Items such as personnel and skills, licensing of personnel for operating support equipment, and maintenance training must be evaluated. A work center that receives no discrepancies from the auditor during an audit is considered to be operating efficiently and effectively. This is not always a good indicator of the work center's performance because the CSEC audit only captures the minimal requirements. This is done primarily through verification of documentation. It does not measure how well the work center is performing maintenance functions or whether the shop personnel are improving themselves or the maintenance processes they are performing. For example, the CSEC audit asks, "Is a comprehensive training and qualification program in effect?" Under the NAMP's QMS; however, the acceptability of the answer to this

question is left to the discretion of the auditor in interpreting what constitutes a comprehensive training program as required by CSEC. [5, Vol. I, p 8-3]

Special audits are conducted as necessary to evaluate specific maintenance tasks, processes, procedures, and programs to determine how well Airmen and POs are trained to perform them. It is not unusual for special audits to be requested by Officers and Chiefs. This is a method for evaluating known deficiencies, quality of workmanship, and determining the adequacy of and adherence to technical publications and instructions. Continued poor performance during the work center audit or the occurrence of a trend of a specific discrepancy indicates a need for unscheduled special audits to evaluate the work center's corrective actions and performance improvements. [5, Vol. I, p 8-3]

C. INTERNATIONAL STANDARDS ORGANIZATION 9000 TRAINING

Each of the ISO 9000 compliant activities visited during this research provides basic orientation training in the activity's quality system to all employees since the quality system pertains to all individuals. This is accomplished with a one or two day program which educates personnel about quality systems in general and the ISO 9000 quality system in particular. [7]

This section focuses on three training elements required by the ISO 9000 standards. They are: (1) the training element 4.18 of ISO 9001, (2) the training aspects of elements 4.17 Internal Quality Audits and 4.20 Statistical Techniques, and (3) the importance of training the employees so that they can initiate continuous process improvements.

Referring to Appendix B, element 4.18 of ISO 9001 requires that documented procedures be established that identify personnel training needs and provide for the training of all personnel whose performance affects the quality of a product or service. It also requires that records be maintained that are appropriate to the training needs of personnel. The building of a training program that incorporates these elements can be accomplished with little or no additional cost to the organization. [31]

For example, at NADEP, Cherry Point, the NEAC's training costs have been minimized by using internal resources whenever possible to build its training program. First, training procedures were reviewed to identify training requirements for employees using a Microsoft Access database. The training coordinator used this system to build and track training requirements for the NEAC and each individual. Second, employees completed required training in-house whenever possible by using their own NADEP resources for instruction. This training is documented in the individuals training record on a computer-based training system or in a training jacket. Second, according to Dr. Laviolette, these computer-based systems are also used to provide inter-active training that enhances the sharing of knowledge during training sessions, the development of internal relationships between different work centers, and the fostering of mutual understanding of each other's jobs and responsibilities. [2]

Again referring to Appendix B, elements 4.17 and 4.20 require training of QM personnel in performing Internal Quality Audits and Statistical Techniques, respectfully. Both types of training are necessary for a QMS to be effective at helping personnel manage product or service quality.

Internal quality audits are key QM tools in evaluating the performance of a QM activity. They are conducted to determine whether QM activities and results are consistent with the planned product or service quality levels and whether these activities are the correct ones for achieving the organization's customer service objectives [6, p 143]. In addition, they can be a valuable resource for making recommendations on how improvements can be made to existing processes. Quite often employees become complacent to the procedures that are in place. During an internal audit, a properly trained auditor can stimulate the employees' cognitive reactions to considering different or improved ways of doing business.

The Lead Auditor course is highly encouraged by each of the ISO 9000 activities that were visited. The Lead Auditor course is forty hours in length, is usually taught on-site at a customer's facilities by ISO 9000 registrars, and explains standards of auditing and what ISO 9000 requires [2]. Lead auditor training is different from regular auditor training in that lead auditor training teaches the auditor how to manage audit personnel that work for the organization in addition to learning auditing skills. Audit training is not concerned with specific skills but rather teaches personnel how to audit. It teaches how to effectively communicate with the party or person being audited, what to look for, and what questions to ask. ISO 9000-trained auditors tailor questions to the organization being looked at and ask questions such as:

1. Tell me about your procedures; how do you use them;
2. Where are the procedures you consult if you have any questions (personnel must be able to easily access and personally show an auditor compliance with a specific product or service quality requirement);
3. Were you trained before you started working alone and can you get that record for me;
4. How do you know when you are making the product correctly, can you tell what is good or bad, show me; and
5. If you have a problem in performing a process, what do you do? [7]

The number of auditors at each organization varies but typically there is at least one lead auditor per division and there may be as many as three to five regular auditors for a division of 50 personnel. Only one auditor is needed to perform an audit. It is recommended that additional auditors be trained so that they can fill in for auditors as necessary and because these auditors bring valuable insight into auditing processes back to their divisions.

The correct application of modern statistical techniques is an important element at all stages of the quality process and is not limited to the post-production or inspection stages. Statistical techniques include reliability testing, Pareto charts, SPC, fishbone diagram analysis, probability theory, hypothesis testing, loss-functions, cost/benefit ratios, and Chi-square analysis. Problem solving techniques that have a statistical element include quality function deployment, failure mode and effects analysis, and benchmarking. The organization may choose to use one or many of these statistical techniques but without the proper training in the use of these techniques, the activity may derive little benefit from their use. [35]

According to the United Airlines Technical Services manager in the Engine Business Unit, statistical techniques enhance the productive effort of personnel by helping them to anticipate problems in production and maintenance processes and material rather than waiting for them to occur. For example, the performance of an aircraft engine can tell a lot about its material condition. Maintenance managers in the Engine Business Unit use engine data that has been collected from operating aircraft and that has been converted to SPC charts and other useful information to monitor the performance of engines. They can identify the engines that are beginning to exhibit less than optimal performance and can then plan for component adjustments or parts replacements at a location commensurate with the skills, test equipment, and parts available for that location. This allows United Airlines to make the transition from a maintenance workload revolves mainly around unscheduled maintenance to one that revolves mainly around scheduled maintenance. This allows variability in the maintenance workload to be reduced from day to day thus reducing the cycle time in completing daily maintenance workloads and reducing the cost of providing logistical support. [25]

Training in data analysis using SPC should give Airmen and POs a fundamental basis in how to read trends in data and SPC charts and forms, including those discussed in Chapter III. All data have a function for one purpose or another, but they do not automatically give the correct signals to help personnel identify quality problems in processes or material. Therefore, data analysis training must help Airmen and POs to decide how to prioritize the data that can be collected at a collection point and to which

data are meaningful and which are not. It must also teach Airmen and POs how to display data in a way that readily shows the important trends. Well-defined parameters shown in concise reports, charts, and tables that clearly show trends in process and material deficiencies can facilitate the development of plans to eliminate these deficiencies. They can make the difference between good and poor data analysis. [25]

Furthermore, training in trend analysis must cover a four-step process—data collection, analysis, modification, and interpretation. First, Airmen and POs must learn how to produce a data baseline, how to decide the minimum amount of data that can be used to establish that baseline, and how to monitor the baseline. They must understand that the only way for trend shifts to be identified in SPC charts and forms is for a baseline to be established. The baseline then allows Airmen and POs to see where upgrades in equipment components, the installation of deficient components or material, and the use of poor maintenance techniques is causing a correction, or shift, in the data. Second, personnel must learn how to analyze data to identify the important trends that may indicate a process or material deficiency. They must be able to intuitively scan data, to select only those data points that will provide meaningful information, and eliminate those data that are not needed. Otherwise, personnel can be overwhelmed with irrelevant and costly data. They must also be able to link the data that are collected with the informational needs of Officers and Chiefs. Third, Airmen and POs must learn how to manipulate data. Because data are collected under conditions with innumerable variations, they must be normalized, or corrected, through mathematical relationships to allow for data that is collected under different actual conditions to be compared under the

same theoretical conditions. Finally, Airmen and POs must be able to interpret data. They must be able to decide what significance the data has to underlying problems in an organization's processes and material and to help Officers and Chiefs decide what actions to take to eliminate those problems. They must also know how the data interact to provide a complete picture of engine performance. [25]

Appendix F gives an example of how meaningful SPC charts can be constructed to monitor aircraft engine performance. United Airlines' engine maintenance facility monitors a significant amount of data. In addition to being monitored in the test cell during routine scheduled maintenance, engine performance data are monitored during routine airline operations. For example, prior to each flight, the pilot is required to take readings from cockpit engine indicators, key-in, and upload engine performance data. This data is transmitted electronically and then downloaded by Engine Business Unit personnel and technicians where it is compiled, recorded, and analyzed using statistical techniques that all personnel have been trained in using. [25]

At United Airlines, the goals and current rates for in-flight shut downs, planned removals, shop visit rates, and service bulletins are continuously monitored. The first chart in Appendix F depicts the goals and current rates of each of the engine types used on United Airlines aircraft. Next on the same page, major discrepancy concern areas are tracked and finally key project areas are listed. The following page depicts the Pratt & Whitney JT8 top five causes of poor maintenance service reliability (MSR). The graphs show the effects these MSR cause on flight delays and cancellations on one graph and the JT8 MSR fleet goal on the other graph. Next, the Engine Stall MSR causal graph

identifies engine stall problems and signals managers to initiate action to solve the engine discrepancies. [25]

The two Module Analysis Program charts for an engine during an engine test cell run for two different time periods show areas of concern for the performance of this engine. The bottom section of this chart shows key data points for three different engine power settings. The first and second sets of numbers are ratios and the third set of numbers shows differences for engine components or engine sections. Specific points have been highlighted as areas of concern. Even though these numbers are within tolerance, they will be monitored after the engine is installed into an aircraft. Organizational maintenance activities normally assess these areas as accept or reject and do not provide follow-up action after the engine is accepted by the activity. Organizational maintenance technicians are not trained or knowledgeable on reading test cell data when accepting an engine. [25]

Following the Module Analysis Program charts in Appendix F, two SPC charts depict the JT8 engine Exhaust Gas Temperature (EGT) Margin Trend and High Pressure Turbine (HPT) Module differences. Based on the EGT Margin Trend, it appears as if this process is out of control. By looking at the HPT Module data, a corresponding upward shift is noted in the data trend. This indicates that each of these areas is in sync with one another and operating properly. In this case, a component on this engine was upgraded that resulted in improved engine performance. The baseline needs to be adjusted to reflect this fleet modification. Without proper tracking methodology, excessive man-

hours and costs might have been devoted to a suspected problem when the system was actually operating normally. [25]

Next in Appendix F is the Modular Performance Assessment for the JT8 engine. The middle box is the O.K. zone. There is a hidden trap in this graph. It is difficult to distinguish between off-setting discrepancies. The technicians can be deceived by this chart if they do not understand that two failing components can pull in opposite directions and cause the chart to read in the O.K. zone. In addition to reading this chart, the technician must be trained to read and understand the baseline values for each of the items listed in each of the corners of this depiction. Some of these values can be seen on the following depiction titled JT8 Modular Analysis for a single JT8 engine. [25]

The following depiction is a JT8 Modular Performance Assessment chart for a single engine (Serial Number 696582). The datum reference baseline figures are provided on the bottom line of the deviations section [28]. The engine test cell Module Assessment graphs show the performance of the same engine previously mentioned (Serial Number 696582) during a test cell run. They display information from data points about a baseline over time. The N2 data has been consistently on the right or positive side of the baseline and is finally back on track for this engine after an extended period of time. The baseline for N2 is (–1.6) and is shown on a previous page entitled JT8 Modular Analysis. The problem turned out to be a component that was consistently improperly installed every time until May 2, 1999. This indicates that insufficient maintenance training may be the cause of the improper installations. [25]

Because continuous process improvement is a basic tenet to the ISO 9000 QMS, Airmen and POs must learn how to achieve it. They can learn how to achieve continuous improvement through ongoing training programs that teach employees how and why processes must be improved. They must always evaluate what processes are being performed, decide whether they are adding value to the organization's output, and continuously improve them. One method used to achieve continuous improvement is to have Airmen and POs learn to use a methodology or technique similar to Toyota's "five whys" exercise. This exercise can be used to systematically track every process deficiency back to its ultimate cause and devise a process improvement that ensures the deficiency never recurs [36, p 57]. The exercise consists of asking a chain of "why" questions, not necessarily limited to five (5), until the root cause of a quality problem is identified [37, p 3].

For example, suppose an organization's employees complain about errors in paychecks and payroll staff complain about long hours due to making the corrections to the paychecks. Currently, the payroll division is staffed with temporary employees, and there is a high turnover rate of temporary employees. The initial solution proposed by managers for this problem is to replace the temporary employees with permanent employees in the payroll staff to reduce the turnover rate. This solution does not eliminate the root cause of the problem, however. The first "why" question is asked as to why the payroll staff must work long hours. The answer is that the staff has to make corrections to errors being made in special pay data entries. The second "why" question is asked. The answer is that the staff is making errors in entering special pay data. The

third “why” question is asked. It is discovered that some special pay data entries were omitted. The fourth “why” question is asked. It is revealed that the temporary employees didn’t know that special pay data entries were necessary. The fifth “why” question is asked. The answer is that training failed to address the special pay data entry requirements. The sixth “why” question is asked. The root cause of the problem was found to be that no explicit guidelines explaining the special pay data entries existed for the temps to use. The final “why” question is, “what can be done to resolve the problem?” The countermeasures to this problem are to establish a process flow chart, to standardize the work procedures, update written guidelines, retrain permanent and temporary personnel, and to improve upon the explicit standard. [37, p 12]

If an organization wants to keep up with the changing environment and other leading organizations, it must be able to evolve and change, and be able to focus on a continuous improvement methodology. This improvement methodology must include an improvement process that is tailored to fit the activity’s needs. The most critical element of a successful improvement process must include the people who must change because it is their support that ultimately determines the success of the organization. This is because they are the ones that change the processes and achieve the desired outcomes. Therefore, they must be trained in not only conducting the processes, but they must also be trained to be resilient, adaptable, and involved in these changing and improving processes.

D. ADVANTAGES OF EACH

The advantages and disadvantages of the NAMP and ISO 9000 training aspects will be discussed in this section. First, the advantages of NAMP training are as follows:

1. NAMP training is designed in such a way that it is easy to modify to improve its effectiveness. For example, the CSEC checklist is a good tool for conducting audits, but should not be the only tool for conducting audits. QM POs should have data analysis, statistical technique skills, and auditing skills to use while in addition to using the CSEC checklist as a guide to assist the auditor. Also, the number of QM POs in an organizational maintenance activity is comparable to the number of ISO 9000 auditors for similar-sized maintenance activities outside Naval aviation. There are approximately eight to twelve QM representatives for an organization consisting of 180 to 220 Airmen and POs. QM POs in Naval aviation organizational maintenance should be required to attend lead auditor training to teach them auditing skills. In addition, some work center personnel should attend either lead auditor or regular auditor training so that they can teach auditing skills to other members of the work center. This will give a maintenance activity the QM skills it needs to assess and improve itself on a continuous basis rather than waiting for an ISO 9000 auditor to identify process deficiencies. [5]

2. The established NAMP training procedures give organizational maintenance activities flexibility to adjust their training requirements to fit their needs. For example, an organizational maintenance activity can schedule training around operational commitments as necessary and are given discretion in selecting the types of training that best fits that activity's requirements. [5]

3. The standardized formal training such as "A" school and NAMTRA, for those that receive this type of training before reporting to a maintenance activity, ensures that personnel reporting to the activity are similarly trained. These schools ensure that there is a relatively equivalent skills level from organizational maintenance activity to organizational maintenance activity (minus skill differences from recruiting efforts). Training differences or discrepancies that arise between similar types of organizational maintenance activities are therefore probably a product of deficiencies in an organizational maintenance activity's internal operating processes (this includes lack of training afforded maintenance personnel) rather than the initial pipeline training that personnel receive. ISO 9000

standards are ideally suited for identifying inefficient practices, enabling maintenance personnel to devise improved practices, documenting these processes, and then implementing these improved processes to improve the activity. [5]

4. The NAMP standardizes training records for Airmen and POs. This ensures consistency, eliminates confusion about what is required, and simplifies the auditing process. The NAMP only gives the minimum requirements for training records and allows some flexibility for the activity to add requirements as appropriate to meet the activity's needs. [5]

Second, the advantages of ISO 9000 training are as follows:

1. Under ISO 9000, an organization is required to document its training procedures and training requirements for the activity and each of the functions within the activity. In addition, the activity is required to maintain a training record on each individual that is employed with that activity. By having documented training procedures, the employees understand what type of training is required for each of the functions performed within the activity. In addition, it forces the activity to address its training system regularly. Since continuous process improvement is a tenet of ISO 9000, it must strive to improve its training processes as well. [38]

2. ISO 9000 requires that a QMS include procedures for identifying statistical techniques in assessing process capability and output characteristics. It also emphasizes that statistical techniques are important to all stages of producing a good or service. Statistical techniques should be employed in all areas where their use will demonstrably improve quality. These areas include process control, process capability, inspection planning, and defect analysis. [31] Therefore, training should be geared to include those individuals responsible for each of the areas listed above. This training will improve the capabilities of both the technicians and the auditors.

3. ISO 9000 requires and emphasizes that auditors be trained in auditing procedures. This ensures that the activity will receive the greatest benefit possible from the auditing process. The audit is a key tool in evaluating the performance of an activity. In addition, it can be a valuable resource for making recommendations for improvements to existing processes. [38]

E. DISADVANTAGES OF EACH

This section lists the disadvantages of NAMP and ISO 9000 standards training procedures. First, the NAMP training disadvantages are as follows:

1. CSEC generates all checklists for audits, provides for collection of discrepancy data, and produces reports but does not teach Airmen and POs how to audit and how to use the data collected. The CSEC becomes the audit, and personnel using this checklist use the checklist to only check compliance without having any knowledge of what they are doing or why they are looking for specific process deficiencies. Interpretation of what constitutes compliance with the CSEC checklist is left to the discretion of the auditor. One auditor may find that the work center's programs are in compliance with the CSEC checklist while another auditor may find the work center is significantly out of compliance with CSEC requirements. [5]

2. Maintenance training received by Airmen and POs prior to reporting onboard can be lost during the period of time in which a person is assigned temporarily to duty that has little relevance to the training s/he received (explained in Chapter VI). When this training is not closely coupled with practice and real-life application, its effectiveness becomes greatly diminished because some or all of the learning they gained during their initial maintenance training is lost due to lack of use. In addition, Airmen and POs may become disinterested in the job they were trained to do when they are not doing that job. Therefore, they may become less effective as maintenance technicians when they finally are able to apply their training. Furthermore, when Airmen and POs finally do start using their training, it is used for a short period of time before they either transfer to another activity or reach the end of their obligated service requirement and separate from military service. [5]

3. Discrepancy trends and/or poor performance results found during the work center audit should indicate a need for unscheduled special audits but little training is provided to QM personnel on how to use trend analysis such as statistical techniques or data analysis. Even the data analyst (DA) in an organizational maintenance activity, who is supposed to be the resident expert in analyzing data, receives little training in trend analysis during "A" or "C" school. Instead, his training focuses on operating NALCOMIS and on how to generate various reports [39]. [5]

4. The QM representatives are expected to have skills and experience related to technical fields but are not required to have data analysis skills that would permit them to effectively evaluate and analyze data for discrepancy trends and potential problems in maintenance processes. [39]

5. Airmen and POs receive little formal training beyond what is required to operate day-to-day within organizational maintenance activities. Therefore, inspections for the transfer of equipment or material between organizational and intermediate level maintenance activities is based on an accept or reject criteria with no follow-up action as to the material condition of that equipment. For example, when the organizational level activity inspects an engine they are looking primarily for material discrepancies. Once accepted, the engine is installed and operated. If it passes this test, the engine is ready for flight. This methodology does not allow for tracking of close-to-range tolerances found in the test cell that may develop into bigger problems shortly after the engine is accepted. [40]

6. The NAMP requires no feedback loop that can be used to ascertain the effectiveness of training. Without this feedback, training cannot be improved to ensure it gives Airmen and POs the skills they need to do their job properly. If personnel cannot do their job properly, they cannot build quality into their production and maintenance techniques [25]. The Army currently uses a system that is used to directly solicit feedback on the effectiveness of training. This system involves the collection of the opinions and suggestions of soldiers during a debriefing immediately after the completion of a training exercise. The information is then stored electronically in database form for Officers and Chiefs to review and learn from prior to the conductance of other similar exercises. [21]

Second, ISO 9000 training disadvantages are:

1. ISO 9000 training requires active participation by management personnel. Managers must be involved to ensure training courses are available and that training time is set aside from productive time for the employees. This requires a paradigm in thinking that is committed to process improvement, a paradigm that is not prevalent in Officers and Chiefs in Naval aviation organizational maintenance, particularly squadron COs and MOs. [5]

2. ISO 9000 does not specify the types of operational training that must be conducted at an activity. This is left to the discretion of the organization's personnel and managers. The organization may try to keep costs down by

conducting all training in-house or limiting available time to conduct training.

3. Results from training may not be immediately apparent and it may be difficult to assess as to the effectiveness of the training. In addition, employees may seek other employment after the organization provides the training.

F. CHAPTER SUMMARY

Training is a very important part of a QMS. In Naval aviation maintenance from the CNO down to all members in an organizational maintenance activity, QM training must be mandated for a QMS to be effective. Although training is required to be accomplished at squadrons, Officers and Chiefs perceive operational commitments to be even more important. Therefore, since training is perceived to be less important, it is ignored as a strategic tool for improving the activity's products or services. In addition, the time that must be committed up-front to the accomplishment of training causes Officers and Chiefs to give little attention to training.

This chapter discussed the importance of proper QM training to bringing about continuous process improvement. ISO 9001 elements 4.17, 4.18, and 4.20 for training, internal quality audits, and the use of statistical techniques, respectively, were discussed. Finally, the advantages and disadvantages of the QM training required by the NAMP and ISO 9000 QMSs were discussed.

VI. INTERNATIONAL STANDARDS ORGANIZATION 9000 IMPLEMENTATION ISSUES AND PERFORMANCE METRICS

A. INTRODUCTION

This chapter discusses ISO 9000 QMS implementation issues and performance metrics as they affect the NAMP. Even the best plans and solutions to recurring quality problems are useless without effective implementation and performance measures. The organization must be constantly vigilant to ensure that these plans and solutions are accepted and practiced throughout the activity and that they become the new standard.

While thorough research into ISO 9000 QMS performance metrics and the actual plan for implementing the ISO 9000 QMS in Naval aviation's organizational maintenance activities is beyond the scope of this research, these two aspects of implementing the ISO 9000 QMS will require the NAMP to be changed. Changes to established NAMP QM policies and procedures must be made for them to be compatible to the ISO 9000 QMS. This chapter therefore identifies the necessary changes and deals with implementation issues as they relate to the NAMP. The specific implementation issues discussed are QM procedures, QM training, and the specific benefits to be gained in the NAMP. In addition, proposed performance measures are presented to support ISO 9000 implementation.

B. IMPLEMENTATION ISSUES

Implementing change within an organization is a complex and dynamic process. Regardless of how well the implementation process is planned and designed, how excited

or resistant people are going into the process, or how positive the long-term outcomes promise to be, issues will arise that make this a difficult evolution. The organization will need to remain committed to its plan throughout the implementation process. The strategy for implementing change will need to be continuously monitored, evaluated, and altered as necessary to ensure the activity can reach its objective of improving its QMS. [35]

Not every organization successfully implements an ISO 9000 QMS, but each of the activities identified throughout this research are realizing substantial quality improvements from implementing and using ISO 9000 standards. While a full research effort is needed to understand why some organizations fail in the ISO 9000 QMS implementation process, a general conclusion can be drawn. The key to understanding why some organizations fail at the ISO 9000 QMS implementation process is to understand the culture that is in place at these organizations. In general, culture is generally resistant to change, may not foster mutual respect of everyone's views, inhibits collaborative efforts to manage quality across functional boundaries, and promotes top-down management. It thrives on the "that-is-the-way-we-have-always-done-it" mentality, minimizes feedback and ownership/involvement from employees at the lowest level, and promotes a lack of trust in employees' ability to be responsible and practice discretion. Managers who support this culture are looking only for QM procedural change that can bring quick results without having to address cultural problems and fail to realize if personnel lack the QM and technical skills needed to improve process quality [2]. This culture is the juxtaposition of the culture found in organizations after they successfully

implement the ISO 9000 QMS. The culture found in the organizations that fail at implementing the ISO 9000 QMS is characteristic of a Directive Configuration, as opposed to a Generative Configuration. [2]

The ISO 9000 QMS and the current policies and procedures the NAMP assigns for organizational maintenance activities are not mutually exclusive [2]. The writing style, or tone, set by the NAMP's QM policies and procedures for organizational maintenance is characteristic of the Directive Configuration. Recall from Chapter II this configuration emphasizes controlling the working environment by standardizing and routinizing tasks. This tone permeates the policies and procedures used to manage organizational maintenance. The occurrence of issues of adaptation and collaboration are minimized because change disrupts orderly operations. These policies and procedures are reminiscent of the culture found at organizations like the ones described above that fail in the ISO 9000 QMS implementation process. The writing style in the sections of the NAMP that deal with organizational maintenance must be changed to help COs, MOs, Officers and Chiefs in Naval aviation generally think more in configurational terms, specifically to think more in generative terms, and reshape the currently prevailing culture in organizational maintenance. This change in the NAMP's writing style must accompany the changes in procedures and training discussed below for meaningful change to be brought about.

1. Procedures

It is possible to make the QMS in the NAMP consistent with the ISO 9000 QMS [33]. Some aspects of the QM procedures in the NAMP are already consistent with the ISO 9000 standards [2]. For example, the NAMP already builds effective QC techniques into the QMS used in Naval aviation organizational maintenance [2]. Also, the ISO 9000 QMS requires the establishment of a QA division to lead an organization's overall QM effort, and the NAMP already establishes such a division in organizational maintenance activities [2].

For Naval organizational maintenance activities to embrace ISO 9000 standards; however, other maintenance management procedures discussed in the NAMP must be modified. Eleven (11) changes must be made. First, the NAMP must either separate those activities unique to the organizational level of maintenance from intermediate activities in Volume I of the NAMP, which establishes the foundation of maintenance programs, policies, and principles for intermediate and organizational maintenance, or embrace ISO 9000 at both the organizational and intermediate levels of maintenance. The NAMP currently promulgates policy and procedures for both levels of maintenance concurrently. The maintenance management policies and procedures for each level of maintenance are not separated into different volumes. If the ISO 9000 QMS is instituted in Naval organizational maintenance activities, but not the intermediate maintenance activities, then the NAMP must separate the policies and procedures for two different QMSs, the ISO 9000 QMS for the organizational maintenance activities and the current

NAMP QMS for intermediate maintenance activities. If the NAMP intermixes the policies and procedures from two different QMSs, internal inconsistencies in between the policies and procedures of the two QMSs will likely confuse Airmen and POs and render the ISO 9000 QMS ineffective. [5]

Second, to be consistent with the ISO 9000 standards, the NAMP must consolidate all the elements of the NAMP's QMS that deal with organizational maintenance into Volume V which contains the NAMPSOPs. These elements are currently scattered throughout the NAMP. Collating them into Volume V would establish a complete QM manual for Naval aviation organizations. Such a manual would satisfy the ISO 9000 requirement for the creation of a quality manual as discussed in Chapter IV. It would also help Officers and Chiefs to view all the separate QM elements scattered throughout the NAMP not as separate stand-alone requirements but as parts of an overall system for managing quality. For example, they could better understand the link between properly training Airmen and POs and the ability of those personnel to practice QA techniques that enable them to build quality into aircraft maintenance. Because of the fragmentation of the current QMS within the NAMP, Officers and Chiefs may fail to recognize this distinction.

Third, the NAMP must capture the fundamental basis of continuous improvement in Naval aviation organizational maintenance. The fundamental basis of continuous process improvement is that personnel must continually ask themselves whether the current processes are the best they can be [2]. This is having insight into the efficaciousness of processes to produce quality products and services [2]. Airmen and

POs cannot assume processes are the best they can be just because "that is the way we have always done it." The processes that over time have remained in place may very well be the best way of doing business at a particular point in time. If this is the case, they should not be tampered with until it is determined that they are not the best way of doing business. Then, at the time when it is determined they are no longer the best way of doing business, they should be changed. Continuous improvement can then be effected using a methodology similar to Toyota's "five whys" exercise discussed in Chapter V. Under the current NAMP QMS, Airmen and POs do not think in these terms. [33]

Fourth, the NAMP must require Officers and Chiefs in Naval aviation organizational maintenance to construct the ISO 9000 process flowchart discussed in Chapter IV. This flowchart would show the complete picture of maintenance management requirements from the NAMP down to the local SOPs. [7]

Fifth, the NAMP must employ an effective QMS that is properly balanced in its incorporation of both aspects of managing quality—QC and QA [2]. Its QM requirements cannot focus solely on the use of inspection and test functions to ensure maintenance conformity with acceptable specifications [8]. These types of techniques focus on oversight to help manage quality [2]. They are costly and unreliable, and can never be counted on by themselves to ensure quality is built into maintenance. The NAMP must also require the use of QA techniques that address the human design factors in building quality maintenance processes. QA techniques educate personnel in how to build quality into aircraft maintenance and provide confidence that aircraft maintenance techniques will conform to the quality standards established by Officers and Chiefs [3]. It

does this by giving personnel insight into building quality into a process [2]. When properly incorporated into a QMS and practiced proficiently, QA techniques can provide the utmost quality, lower discrepancy rates, lower rework efforts, lower quality control costs, and even reduce the need for QC [8].

Sixth, the NAMP must describe the procedure for implementing and maintaining the ISO 9000 QMS. This process should involve the six steps outlined in Chapter III—assessment, planning, upgrading (or redesigning), implementation, auditing, and continuous improvement. Of all the QMS implementation methods available, this procedure is the most relevant to squadrons.

Seventh, Airmen and POs need to have access to a database of discrepancies to assist with troubleshooting procedures [25]. QM POs have limited access to maintenance data that cover extended periods of time making it difficult to perform trend and other types of analysis. These data are currently accessible through an "ad hoc" query in NALCOMIS, but it is difficult to retrieve and group into meaningful metrics. Furthermore, due to the lack of NALCOMIS computer capacity for training in and performance of trend analysis using the "ad hoc" query, QA Division representatives and work center supervisors are frequently discouraged from using the "ad hoc" query [29]. It is therefore difficult to perform trend analysis to draw conclusions about quality problems in aircraft maintenance and harder to troubleshoot maintenance discrepancies. Denying QM and maintenance personnel access to this invaluable QM tool makes it harder for them to perform their job more effectively. The NAMP must require that better access to maintenance data be available to QM and maintenance personnel. [39]

Eighth, a more effective process for recommending and submitting changes and corrections to maintenance-related instructions and publications must be built into the NAMP. The current process is cumbersome and fragmented, and it provides an inadequate means of sending feedback to those submitting the changes. It is not supported by adequate engineering expertise to ensure timely responses to change requests, and the engineering expertise that is available lacks a practical understanding of the system repairs that are in question. The result is that the response system can be quickly overburdened, and when changes to maintenance instructions and publications are made, they may further complicate a process for repairing a particular system. Additionally, the format for submitting such changes is time-consuming and cannot be quickly laid out. Furthermore, information about discrepancies is not shared by activities that have previously experienced a particular maintenance problem with other activities that may be currently experiencing the same problems [Vol. I, p 10-2]. It is also not readily available for Airmen and POs to access during troubleshooting procedures [25]. [40]

Ninth, due to frequent rotation of QM POs, the QA Division in organizational maintenance activities sometimes suffers in its ability to bring about improvements in aircraft maintenance quality. The rotation creates a lack of consistency in core QM skills and experience level within the QA Division. This effect is further exacerbated when Officers and Chiefs place higher priority and commitment to filling production work center billets with their best POs. Officers and Chiefs rotate solid performers in the QA Division to other work centers right after they acquire a good grasp of QM techniques but

before these performers can make a positive impact on QM in the maintenance activity. Likewise, those POs who are not the best performers may be rotated into the QA Division. The NAMP must clearly discuss the importance of Officers and Chiefs being committed to building effective QMSs by manning the QA Division with the most competent QM representatives. It must also require QM representatives to remain in the QA Division for longer than a year. This will improve the consistency of core skills and experience level within the QA Division. [39]

It may be possible to develop a classification system for QM billets that ensures a permanent pool of well-trained, experienced QM POs are available from which QM billets at organizational maintenance activities can be filled [39]. A thorough discussion of such a system is reserved for future research on the implementation of the ISO 9000 QMS in squadrons.

Tenth, the NAMP must require formal registration of squadrons. One of the driving forces behind commercial organizations becoming ISO 9000 registered is that their customers require it. There is no such driving force compelling squadrons to become ISO 9000 registered. Nevertheless, being formally required to become ISO 9000 registered will force squadrons to be disciplined in their approach to the implementation of the ISO 9000 QMS and standardization of process quality. If they do not take this disciplined approach, they may be tempted to adopt only some or none of the parts of the ISO 9000 QMS. However, as discussed in Chapter II, the ISO 9000 QMS must be adopted in its entirety or it may be ineffective.

Eleventh, the NAMPSOPs in Volume V of the NAMP will need to be modified to make them consistent with the ISO 9000 standards. The totality of the modifications to each of the NAMPSOPs is likely to be unique to each respective NAMPSOP. Appendix E shows examples of the "Employee Training, Certification, and Qualifications Program" SOP used in the T-45TS program before and after it became ISO 9000 registered. These examples serve as general guideline for the types of NAMPSOP modifications that an ISO 9000 auditor likely would want to see. There are five changes to discuss.

The first change is the change from program management to process management. Because the basis for the ISO 9000 QMS is process management, not program management, the responsibility for reviewing an SOP is given to a process manager, not a program manager [25]. Although the process manager and program manager may coincidentally be same person, many times, a process is established under a different manager. The program manager may be arbitrarily assigned, but the process manager is the person who is most intimately involved with that process. S/he is the most logical person to whom responsibility for a process should be assigned. S/he is in charge of maintaining, updating, and improving all aspects of the process. In the case of the sample T-45TS SOPs in Appendix E, the process and program managers are not same. Referring to Page 1 of each of the SOPs, the program manager was the Quality Control work center supervisor. The SOP is now assigned to the Training Coordinator, the process manager, because he is the owner of the process of training, certifying, and qualifying employees. [33]

The second change involves the QC responsibilities. In the case of the T-45TS QC Division, management of the process of training, certifying, and qualifying employees has been reassigned from the QC Division to the Training Coordinator, thus modifying the QC Division's responsibilities. Referring to the QC sub-sections on Page 3 of both SOPs in Appendix E, QC no longer has the responsibility of managing the program and assigning the Training Coordinator to implement and coordinate the training requirements for the T-45TS program. The Training Coordinator would now most likely be appointed by the Assistant Maintenance Officer at an organizational maintenance activity. The QC Division only monitors the process for compliance with the "Employee Training, Certification, and Qualifications Program" SOP. [33]

The third change is the elimination of unnecessary processes. During audits, and during the construction of the flowdown matrix discussed above, some processes that are contained within an organization's existing documentation may be deemed as unnecessary. These processes may be obsolete or they may be absorbed as a part of another process. In cases such as these, processes may be eliminated. Referring to Pages 4 and 5 of the old SOP in Appendix E, some of the "tasks/jobs/programs" that fell under this particular SOP for qualification or certification have been eliminated from Pages 3 and 4 of the new SOP. They either are not needed or fall under another SOP. These include shipboard aircraft firefighting, final checker, closehole tolerance certification, and coldworking certification. Also, the qualification/certification processes for corrosion control technicians and aircraft painters have been combined in the new SOP. This is

because the qualification process for each of these jobs is very similar and the processes of treating corrosion and painting aircraft are inextricably linked together.

The fourth change is the moving of the "note" on Page 5 of the old SOP in Appendix E to the top of Page 5 in the new SOP. This note pertains to the conductance of training classes for qualification and certification because it notifies work center supervisors and the QC Division when personnel have expiring qualifications and certifications. It therefore should logically be grouped with the "T45TS Training Attendance Sheet" that also pertains to the the conductance of training classes for qualification and certification. When the ISO 9000 auditor audited the T-45TS Program, he required this grouping to be made. [33]

The fifth change is the creation of a process flowchart based on the general systems model. Maintenance SOPs generally describe a process flow in textual form, but not in graphical form. This is particularly true of NAMPSOPs. Maintenance personnel; however, frequently do not have time to thoroughly read through SOPs every time they need to perform a process. It is much quicker for maintenance personnel to see a process flow than to read about it. A process that is formatted in graphical form is much more readily usable. Furthermore, referring to the last page of both the old and new SOP in Appendix E, the graphical form of the qualification and certification process had to be changed. Although the old process map depicted the qualification and certification in graphical form, the ISO 9000 auditor required that the processes be modeled along the general systems/process model—input, transformation, and output. Using the general

systems/process model aids personnel in thinking about a process not in terms of so many disjointed steps but as a holistic entity. [33]

The NAMP must establish improved QM and maintenance training processes to ensure the new QMS that would be created within organizational maintenance is balanced between the use of QA and QC techniques and is efficacious in bringing about continuous process improvement.

In addition to making the procedural changes discussed above, the NAMP must establish some additional roles and responsibilities to ensure the ISO 9000 QMS is effectively implemented.

2. Roles and Responsibilities

For Naval organizational maintenance activities to construct an effective QMS, additional roles and responsibilities must be introduced into the NAMP's QMS. These roles and responsibilities will require that all personnel, particularly Officers and Chiefs, at all levels of a squadron become involved in the construction of the squadron's QMS and consistently and intensely support its operation. Five (5) separate areas of roles and responsibilities must either be added to or changed within the NAMP.

First, the NAMP must describe the responsibility Officers and Chiefs in Naval aviation organizational maintenance have to support the building of an effective QMS. All maintenance Officers and Chiefs, particularly squadron COs and MOs, must demonstrate personal leadership and involvement in creating and sustaining a customer focus and clear and visible quality values, and they must integrate these quality values

into the organization's QMS. The single most important element of any QMS is management's responsibility is active involvement in building and supporting that QMS. The consistency and intensity of management's involvement in process improvement directly correlates to how well and how quickly improved processes can be implemented. Officers and Chiefs must support the building of a QMS that is balanced in its use of QC and QC techniques. This support includes a rigorous QM training plan that gives Airmen and POs (1) the skills they need to do their job properly and (2) the skills they need to ensure they build quality into their maintenance techniques. Officers and Chiefs cannot allow support of operational commitments to take priority over this training.

Second, NAMP must describe the roles and responsibilities associated with the change management methodology discussed in Chapter II, Organizational Change Management (OCM) [6]. These roles include the initiating sponsor, the change agent, the change target, and the crisis. As discussed in Chapter II, the initiating sponsor would likely be N88, the change agents would come from within NAVAIR and N88's staff, the change target would be squadrons, and the crisis would be the threat to Naval aviation of losing its mission if it cannot provide logistical support to aircraft in a more cost-effective manner.

Third, the role AMMTs play in bringing about continuous process improvement must be expanded. They already disseminate best maintenance practices and standardize them through their use of "maintenance grams." These maintenance grams, sent at large to the Naval aviation maintenance community, are Naval messages that discuss recent AMMT audit findings. These findings include inconsistencies, inadequacies, and non-

compliances in maintenance practice. The findings also discuss new and better maintenance techniques and management methodologies that have been observed by the AMMTs during their audits. This role of disseminating best practices can be expanded. As discussed in Chapter IV, AMMTs must be empowered to artificially capture the market feedback mechanism that exists in commercial industry. [39]

In this expanded role, AMMTs should travel to commercial maintenance organizations to observe the best maintenance practices being used at organizations such as United Airlines. Commercial maintenance organizations are driven to improve their processes based on market response from customers. Although this kind of feedback mechanism is absent in Government entities like squadrons, it can be artificially captured when best practices are brought from commercial industry to government activities. AMMTs can serve as the bridge between the market feedback mechanism found in commercial aviation maintenance activities and the non-commercially driven operating environment found in squadrons.

Fourth, the most recent versions of the NAMP reassigns the DA from the QA Division to the Maintenance Administration Division as a work center supervisor. When the NAMP reassigned the DA to the Maintenance Administration Division, the ability of QA Division POs to perform trend analysis suffered [29]. The QM data analysis and trend analysis that s/he used to perform is no longer being done [29]. The NAMP must reassign the DA to the QA division. When the NAMP assigned the DA to the QA Division, the DA and QA Division representatives worked closely together to perform trend analysis and identify QM problems in an organizational maintenance activity's

processes. The DA is the most knowledgeable person in an organizational maintenance activity in performing trend analysis and using SPC. If other representatives of the QA Division are not formally trained in trend analysis and SPC, they could learn informally from the DA. The DA continues to track data for the 3-M Summary, but s/he performs little trend analysis because his/her focus is on supporting maintenance administration, and not performing QM for the entire organization. Also, the level of interaction between the DA and QA Division representatives is significantly reduced because the DA is called upon to take a greater role in maintenance administration than when s/he was assigned to the QA Division [29]. [39]

Fifth, maintenance instruction manuals (MIMs) are the foundation to QA in squadrons. They are the first tool available to maintenance technicians to ensure that QA is employed [29]. Airmen and POs; however, frequently do not use them for a variety of reasons. MIMs are cumbersome, poorly written, or too time-intensive to read, and maintenance Officers and Chiefs do little to encourage their use. Airmen and POs must use them more to improve the quality of their maintenance techniques. It is incumbent upon Officers and Chiefs in organizational maintenance to ensure MIMs are used and followed. It is also incumbent upon Airmen and POs to display integrity in ensuring that they use them. The NAMP must clearly mandate these responsibilities. [40]

3. Training

The NAMP's approach to QM training is a by-product of the paradigm in thinking that accompanies Naval aviation maintenance activities' Directive Configuration.

Officers and Chiefs in Naval aviation maintenance think that just because Airmen and POs continually rotate from duty station to duty station and from aircraft platform to aircraft platform, they must be thought of as "replaceable," a characteristic of the Directive Configuration. They believe that each individual only adds value to the management of aviation maintenance through their adherence to the maintenance techniques they are trained to perform. Airmen and POs cannot be trusted to understand how maintenance processes could be performed better or to understand the consequences of not building quality into their work. Officers and Chiefs in Naval aviation maintenance attack the personnel rotation problem solely by standardizing all maintenance processes and incorporating processes improvements by means of a top-down approach. Then, they teach Airmen and POs to follow established maintenance processes without deviating from them. Next, they teach Airmen and POs how to use feedback channels to suggest maintenance process improvements but mire these channels down in a hierarchical review process. Finally, they institute this training methodology in the NAMP. [21]

This QM training methodology sways heavily toward QC and relies less on QA. It is only partially successful at QM because QC training must be balanced by QA training for a QMS to be effective [2]. Naval aviation Airmen and POs receive little training in QA techniques. Officers and Chiefs assume that new Airmen and POs are incapable of making a profound impact in improving maintenance processes. Because it is easier to ingrain new processes into new employees, new employees at the lowest levels can effect process improvements more readily than more experienced employees

who are biased toward old operating methods and procedures [2]. Also, Airmen and POs are properly trained to perform a particular maintenance action, they should be able to do it correctly the first time, every time. To be consistent with the ISO 9000 QMS, the NAMP's writing style must promote empowerment of Airmen and POs at the lowest levels to bring about continuous improvement.

Furthermore, the concept of assigning Airmen and POs Temporary Additional Duty (TAD) for six months or more after they arrive to their initial assignment reduces the effectiveness of the QA training that maintenance personnel receive. For employees to have the insight to know when they are building quality into their work, they must be properly trained [7]. Proper training in QA involves two types of understanding: (1) theoretical understanding of how to perform a process and (2) intuitive or practical understanding of when a theory must be changed to allow a process to be performed better. Airmen and POs must have both of types of understanding to be effective at practicing QA. Having both types of understanding helps maintenance personnel bring about continuous improvement because they not only understand the technical theories of maintenance, they come to understand how to improve these theories. They gain the ability to build quality into their maintenance. The technical schools maintenance personnel initially attend—"A" school, sometimes "C" school, and NAMTRA—provide them with the theoretical understanding to know the proper way to perform maintenance techniques. [40]

The second type of understanding of maintenance techniques comes from practical training, including OJT. This second type of training consummates the

theoretical with the practical—theories in maintenance manuals with real aircraft systems. In the work center, maintenance personnel begin to see through the "clouds," or technical topics that are not quite understood, surrounding the theories they have learned in the classroom. They see these theoretical systems and maintenance processes in real-world aircraft systems. The "clouds" they acquire from studying theoretical maintenance processes in academic material begin to dissipate. Maintenance technicians work through the "clouds" as they see theory put into practice through their working with real systems and through their performance of actual maintenance processes. OJT facilitates the transformation of theoretical understanding of systems and maintenance processes into a more intuitive, practical understanding. Sending Airmen and POs TAD reduces the effectiveness of QA training because it delays the transformation of theoretical understanding into intuitive understanding. [40]

It is therefore critical to send Airmen and POs immediately to the work center for three reasons. First, spending time in the work center right away reinforces the theoretical learning from the classroom. Second, Airmen and POs straight out of "A" and "C" schools are generally interested in the areas of expertise in which they have been trained. Because they are interested in what they have studied, they learn more about their area of expertise faster and retain more. TAD assignments cause maintenance personnel to lose interest in studying their areas of expertise, and then Officers and Chiefs face a daunting task in attempting to regain that interest. [40]

Third, sending maintenance personnel to the work center gives them the OJT opportunities needed to transform their theoretical understanding to intuitive

understanding. Maintenance personnel must be able to work in the work center shortly after completion of their basic training while the "clouds" are fresh, so as not to lose any learning. Sending Airmen and POs TAD immediately after school means that the "clouds" never clear up, get cloudier, or are forgotten completely, causing valuable training to be wasted. Therefore, the NAMP must eliminate the practice of sending maintenance personnel to a TAD assignment away from the work center in which they are trained to work. [40]

To be consistent with the ISO 9000 QMS, the NAMP must also strengthen the QA aspect of its QMS by mandating eight critical elements of QA training. Mandating these elements will help inculcate maintenance and QM POs and Officers and Chiefs with the ability to build quality into aircraft maintenance. These elements build the fundamental thought processes that Airmen and POs need to gain insight into building quality into their maintenance techniques. The first element is to require that all Naval aviation Airmen and POs attend basic aircraft maintenance at "A" school. While many Naval aviation maintenance personnel attend an "A" school, many do not. If Airmen and POs do not attend this basic maintenance training, they must acquire their theoretical understanding from their maintenance manuals and from other personnel. Inevitably, not teaching Airmen and POs maintenance theory introduces variability in the theoretical understanding from one maintenance technician to another. Variability in the theoretical understanding from maintenance personnel to maintenance personnel results in increased variability in the ability of maintenance personnel to build quality into a product. [40]

The second element is to reinstitute the Fleet Replacement Aviation Maintenance Program (FRAMP) program at the Fleet Replacement Squadrons, but with a standardized training syllabus. Technician expertise can neither be supplanted in MIMs nor taught in the classroom environment. Also, "A" school, "C" school and NAMTRA do not provide heat-of-the-moment training. Additionally, NAMTRAGRUDETs are limited in what types of discrepancies they can reproduce. They generally have access only to static aircraft, not operational aircraft that have real-world discrepancies such as structural overstresses resulting from hard landings. This type of practical, real-world training; however, is what is needed by Airmen and POs to build intuitive understanding of maintenance processes and techniques. Therefore, it is essential to give Airmen and POs real-time troubleshooting training on live aircraft, when operationally practical, with real maintenance discrepancies. [40]

FRAMP gives maintenance technicians this real-time, hands-on troubleshooting training thus allowing theories learned in "A" school, "C" school, and NAMTRAGRUDETs to "gel." It also allows Officers and Chiefs and instructors to begin drawing out of personnel their value as maintenance technicians earlier than when the personnel reach aviation maintenance activities. Airmen and POs report to maintenance activities already possessing a minimum degree of practical understanding. Therefore, the amount of time Airmen and POs must spend in the work center familiarizing themselves with aircraft systems is reduced. [40]

FRAMP was used until recently to provide this real-time training, but it was disestablished because the Naval aviation Officers and Chiefs could not agree upon a

standardized training syllabus. The degree of intuitive understanding that Airmen and POs gained from attending FRAMP varied from person to person. Disestablishing FRAMP further exacerbated this variability problem. What standardization there was in inculcating Airmen and POs with intuitive understanding of maintenance procedures and processes is now gone. The result is that the variability in the intuitive understanding Airmen and POs when they are first assigned to a maintenance activity is now even greater. Also, because Airmen and POs tend not to initially have the intuitive understanding needed when they get assigned to work centers, they are assigned duties as a "go for." Airmen and POs do not acquire many new maintenance skills working as a "go for." Consequently, working as a "go for" delays the transformation process from theoretical to intuitive understanding to an even later time. [40]

The third element is to require ethics training in the curricula taught at the "A" school, "C" school, and NAMTRAGRU. This allows Airmen and POs to discuss the consequences of their actions when they fail to build quality into their maintenance techniques. Having this training reinforces the sense of obligation Airmen and POs feel to perform maintenance procedures and processes correctly the first time, every time. Introducing ethics training into these initial maintenance training courses allows Officers and Chiefs and instructors to begin instilling sound values into Airmen and POs early on in their careers. Ethics training helps build integrity into maintenance training [33]. [40]

Some ethics training is currently provided in "A" school, "C" school, and NAMTRAGRU, but this training is not standardized. There is subjectivity from instructor to instructor in teaching specific ethics lessons. This introduces variability into

the understanding Airmen and POs have of the consequences of their actions when they fail to build quality into their maintenance techniques. However, each lesson in the initial maintenance training courses could employ separate standardized ethics teaching points when the instructor explains the importance of the lesson. The NAMP should require that this ethics training be provided. [40]

The fourth element is to strengthen the understanding that Officers and Chiefs have of their role in strengthening a maintenance activity's QA. ISO 9000 compliant organizations can perform poorly if the employees do not have integrity. The ISO 9000 QMS requires a level of discipline, and if Airmen and POs take shortcuts, then the ISO 9000 QMS breaks down. It takes leadership, particularly from work center supervisors, to help Naval aviation maintenance's young maintenance technicians realize the importance of practicing integrity when accomplishing aircraft maintenance [33]. At the same time, Officers and Chiefs must understand that every maintenance technician can bring value to the maintenance effort. It is up to Officers and Chiefs to "mine" this value out of maintenance technicians, particularly those that are new accessions to the Navy. The NAMP must clearly describe this role that must be undertaken by Officers and Chiefs. [40]

The fifth element is to teach auditors how to properly audit, not just what to audit. Auditor training teaches QM auditors how to intuitively find aspects of processes that perform less than optimally. This brings about quality improvements in aircraft maintenance that are tied directly to process improvements, which is a QA technique. This is different from discovering of flaws in aircraft maintenance after it has been

performed, which is a QC method for managing quality. Enhancements to the quality of aircraft maintenance that are brought about by process improvement are far superior to the enhancements brought about through QC. This is so for two reasons. The first reason is that process deficiencies are discovered before they result in flaws in aircraft maintenance, not after. Second, root causes of process deficiencies are more likely to be discovered through QA techniques rather than through QC techniques that might uncover only secondary causes of process deficiencies. [2]

QM POs in squadrons currently learn what to audit from other QM POs. Each QM representative learns auditing skills by watching other QM POs conduct audits and from the program elements identified during AMMT visits as not complying with the NAMP or other governing regulations. QM POs experience a huge learning curve upon initial assignment to the work center, and during this learning period, they are able to make only marginal contributions to the work center's QA effectiveness [29]. Also, because this training is based largely upon passdown from QM representative to QM representative, there is variability in the depth and comprehensiveness of the auditing training received by each QM representative. Additionally, because this training is not standardized, the variability in depth and comprehensiveness of auditing training contributes to the variability in auditing competency of each QM representative. Furthermore, formal classroom auditing training focuses on helping QM POs learn what elements in a maintenance program need to be audited [33]. It does not help QM POs learn how to verify program compliance, ask for verification of program compliance, or identify process deficiencies. Sending QM POs to the ISO 9000 lead auditors class or

some other equivalent would give QM POs the training they need to learn how to audit, not just what to audit. [39]

The sixth element is to teach QM POs, including the DA, SPC and trend analysis techniques [7]. This training provides QM POs with powerful tools to identify process deficiencies that are occurring over time. Using these techniques, QM POs can then act to improve processes and prevent poor quality maintenance from being performed in the future. Currently, however, QM POs receive this training through OJT by means of passdown from QM representative to QM representative. There is no standardization in this training. Again, the effect of not standardizing training is the increased variability introduced into the depth and comprehensiveness of the training received by each QM representative. [29] The Joint Aviation Supply and Maintenance Material Management (JASMMM) teaches such tools [29]. This training could also be built into the initial maintenance training courses for the DA and QM POs. [40]

The seventh element is to standardize maintenance OJT and Personnel Qualification Standards (PQS) for performing maintenance processes. Standardization of OJT/PQS training reduces the variability introduced in the depth and comprehensiveness of the training received by Airmen and POs. The Type Wings are already beginning to effect the standardization of the OJT/PQS, but this must be mandated by the NAMP [39]. OJT/PQS must include to the maximum extent possible training in trouble-shooting techniques. Airmen and POs must receive a minimum level of training to ensure maintenance processes and techniques are performed the same from technician to technician. This ensures quality is built into these maintenance practices and processes.

To the maximum extent possible, OJT/PQS must also capture the expertise of performing unscheduled maintenance processes that are universally used for a particular type, model, and series of aircraft [39]. Furthermore, there must be a system instituted that tracks OJT and is easy to use by Airmen and POs [25]. As well, the effectiveness of OJT to give maintenance personnel intuitive, or practical, understanding depends on the integrity of Officers and Chiefs to ensure OJT is properly administered. [29]

The eighth element is for the NAMP to require NAMTRAGRU to conduct refresher maintenance training for organizational maintenance activities. Refresher training should be conducted on a recurring basis and on an as-needed basis, particularly when a maintenance activity's technicians demonstrate weakness in a particular maintenance process or technique. SPC, trend analysis, and audits would help identify where refresher training would be needed. This maintenance training is currently conducted in-house by the maintenance activity itself and can be easily compromised. Also, if the activity is weak in a particular maintenance process or technique, it probably does not have the resident expertise to conduct effective refresher training. The NAMP should formalize such refresher training because this type of training ensures that organizational maintenance activities retain a minimum core of maintenance skills despite the rapid turnover of personnel. [29]

Making these QM procedural, responsibilities, and training changes to the NAMP's QMS will bring about several benefits.

4. Benefits

There are ten (10) benefits to be gained by squadrons when ISO-9000-consistent modifications are made to sections of the NAMP that deal with organizational maintenance. They are:

1. The ISO 9000 QMS encourages new personnel to think about what type of training they need to help them best do their jobs. This ability gives them the insight to tailor maintenance training in a way that makes it more effective in ensuring that QA is practiced. [7]

2. The continuous improvement and implementation processes brought about by ISO 9000 help managers clarify on what core competencies Naval aviation organizational maintenance should focus. This helps managers establish priorities in the accomplishment of aircraft maintenance and eliminate unnecessary processes. [7]

3. The ISO 9000 QMS helps personnel focus on those maintenance processes that are performing correctly and developing updated replacement processes for those that are not. This prevents maintenance personnel from wasting time and effort on poorly performing processes. [7]

4. The ISO 9000 QMS gets all personnel involved in improving the process, not just managing [7]. It promotes process ownership by employees at the lowest levels in an organization, and so they become enthusiastic about writing their own procedures. They know that they are respected as professionals and can take an active role in shaping the direction of organizational maintenance. They also feel they are being held accountable for the performance of those maintenance processes that they own. [33]

5. The ISO 9000 QMS allows standardization among all operating activities, more so than the NAMP. This allows the performance of one activity to be compared to that of another. Process deficiencies may be more readily identified. [7]

6. The ISO 9000 QMS unites separate but related SOPs under one common process. This eliminates redundancy in the performance of operational functions. [7]

7. The ISO 9000 QMS brings a disciplined approach to streamlining processes. Instructions are linked from the highest echelon to the lowest echelon and overlapping requirements in instructions are eliminated. This eliminates redundancy in paperwork. [7]

8. The ISO 9000 QMS brings focus to processes in such a way that people understand them and can improve them. Better understanding of processes gives personnel more insight into how to improve processes. [7]

9. ISO 9000 brings flexibility in achieving QM because personnel at all levels are empowered to bring about continuous improvement to maintenance process. A QMS can therefore be more readily improved to make it more effective at monitoring the quality of products or services. [7]

10. The ISO 9000 QMS helps personnel see process deficiencies that were missed in audits before the implementation of the ISO 9000 QMS[25]. The comprehensiveness of continuous improvements to QMSs is increased. [7]

In additional to the procedural and training changes that must be instituted by the NAMP, the NAMP must require that performance metrics be used to monitor the effectiveness of the ISO 9000 QMS.

C. PERFORMANCE METRICS

A comprehensive discussion of performance metrics that can be used to monitor the performance of the ISO 9000 QMS in squadrons is beyond the scope of this thesis. Nevertheless, because carefully constructed and well-thought-out performance metrics can be effective in monitoring the efficaciousness of processes to produce quality maintenance, the NAMP must require their use in Naval aviation organizational maintenance. These metrics must be standardized to allow performance results to be compared between organizational maintenance activities. These metrics flow from the

topmost objective(s) in the NAMP to the lowest NAMPSOP, all building upon and supporting each other. To ensure that the types of performance metrics being used are standardized among organizational maintenance activities, the NAMP must establish which performance metrics should be used. Because the NAMP must be changed to include new metrics, this thesis should provide some overall guidance about which metrics might be required.

Although the NAMP already requires the development of some performance metrics, such as the monthly Foreign Object Damage and Cannibalization Rate monitors for inclusion in the Monthly Material Management (3-M) Summary, these metrics are shallow in their depth and thus limited in their usefulness. The NAMP must discuss other additional metrics that Officers and Chiefs can use in more meaningful ways to measure process effectiveness.

Carefully constructed and well-thought-out performance metrics have four general characteristics. First, by demonstrating process results, they should tell an organization how well it is achieving its goals. Second, they must be limited to a vital few that cover key performance dimensions and help an organization to assess accomplishments and costs, make decisions, realign processes, assign accountability, and promote continuous improvement. Third, they must account for the balance organizations must strike between competing demands such as cost, product or service quality, and customer satisfaction. Fourth, they must be linked directly to an organization's responsible personnel or divisions that have responsibility for managing processes. This linking

reinforces accountability and ensures processes contribute to the results an organization is attempting to achieve. [41]

In addition to those performance metrics that are already included in the 3-M Summary, the NAMP should require several additional performance metrics be used by Officers and Chiefs in Naval aviation organizational maintenance. A few are provided in this thesis to give some direction to future research in this area. The metrics that should be required by the NAMP can be separated into two categories.

First, the NAMP must require the monitoring of QM training to allow Officers and Chiefs to assess how effective this training is. Three (3) examples follow. First, QM-related questions can be included on rating exams. These questions should test an individual's ability to recognize when maintenance actions are caused by QM problems, not technical problems. Second, training feedback loops can be monitored by directly linking them to metrics. These metrics would show the effectiveness of training, formal and informal, and how training could be improved to: (1) give personnel the technical skills they need to do their job properly and (2) give them QM skills to ensure they build quality into their maintenance techniques. For example, QM qualification elements on PQSs could be included and tested for comprehension. The direct feedback sessions discussed in Chapter V can also be used to ascertain whether this training is effective. Data from these feedback sessions can then be collated into metrics for Officers and Chiefs to make decisions about how to adjust the training and improve the efficaciousness of this training to inculcate Airmen and POs with QM skills.

Second, the NAMP must require the collection of maintenance data that documents and highlights quality problems in Naval aviation organizational maintenance. This data must be collated so that problems are made readily apparent. Data should be collected at two levels: (1) at the Naval Safety Center for flight mishaps and incidents caused by QM problems, and (2) in organizational maintenance activities to identify repeat and other maintenance discrepancies stemming from QM problems. Organizational maintenance activities already perform some categorization of data that is related to QM problems, but this is scant and not very revealing of QM problems. The NAMP should describe what data should be collected to create the best metrics for analyzing QM problems. Use of these data collection procedures and metrics must be formalized.

Five examples of this category of metrics follow. First, the SPC charts shown in Appendix F must be used as metrics because they enable maintenance managers to monitor both visually and numerically, the material condition of systems. From these metrics, maintenance mal-practice and supply problems can be indirectly identified. For example, an improperly torqued bolt will show up in these graphs as an engine vibration that is causing an engine component to perform poorly. Managers can then investigate the root cause of why the bolt was not properly torqued. Second, the top five maintenance reliability issues must be monitored in a performance metric. This type of metric allows maintenance managers to identify poorly performing processes that drive poor reliability. Third, the number of aeronautical component removals per 1000 flight hours must be monitored. Each component removal consumes manpower and fiscal

resources. This metric thus allows maintenance managers to control the number of removals to prevent resources from being employed needlessly in unnecessary maintenance actions. Fourth, the number of in-flight maintenance discrepancies per 1000 flight hours must be monitored. This metric allows maintenance managers to identify process deficiencies and then to determine the root causes of the in-flight maintenance discrepancies. Fifth, the ratio of unscheduled to scheduled maintenance actions must be monitored. This metric helps maintenance managers assess the whether their manpower, materiel, and fiscal resources are being utilized efficiently. If maintenance managers allow a maintenance workload to be dominated by unscheduled maintenance, the maintenance workload will dictate the use of resources and maintenance managers will be forced into a reactionary role. They will not be able to plan for the most efficient use of resources. Sixth, mean time to repair (MTTR) should be plotted against the number of hours required by the MIMs to perform maintenance actions. This would allow maintenance managers to see how efficiently the ISO 9000 QMS is allowing them to manage their manpower resources [32].

D. CHAPTER SUMMARY

This chapter discussed issues of QA, QC, and performance metrics as they relate to implementing the ISO 9000 QMS in Naval aviation organizational maintenance. The implementation issues discussed included the changes in QM training, procedures, and policies that must be instituted by the NAMP for the QMS within the NAMP to be made compatible with the ISO 9000 QMS. The benefits of instituting these changes were then

discussed. Next, the performance metrics that the NAMP should establish to monitor performance of the ISO 9000 QMS were described. While the intent of this chapter is not to discuss all the aspects of developing performance metrics, the NAMP must institute these metrics because ISO 9000 clause 4.9 requires addressing how these metrics will be used.

The next chapter presents a summary of the findings of this thesis. First, the QM topics discussed in this thesis are presented. Next, the conclusions made from this research are listed and their significance is briefly explained. Then, the recommendations for changes to QM in Naval aviation organizational maintenance are presented, and arguments that support those recommendations are detailed. Finally, topics that are not included in this thesis but which are important to this area of research are recommended for further study.

VII. CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

For approximately 40 years, squadrons have managed quality using NAMP policies and procedures. However, the NAMP QM guidelines rely more on QC and less on QA to manage quality. While the QMS established under the NAMP guidelines has been effective in reducing the number of quality-control-related incidences, the annual number of these incidences is still unacceptably high. Furthermore, the annual rate of occurrences of these incidences has been relatively stable for at least 10 years. This suggests that the ability of Naval aviation maintenance, using the NAMP QMS, to improve its safety record and maintenance practices has probably reached a plateau.

The primary goal of Naval aviation maintenance; however, is to continuously provide the highest quality product (aircraft and related systems maintenance production) while improving the efficiency and effectiveness of maintenance processes. By giving Airmen and POs quality insight into day-to-day maintenance processes and procedures, the ability of Naval aviation maintenance to further improve its safety record and maintenance practices may again be rejuvenated.

The QM procedures and policies currently instituted by the NAMP should help an organization achieve continual process improvement. However, process improvements at the organizational level of maintenance in Naval aviation focus solely on increasing operational availability and sortie completion rates while reducing costs. This methodology is counter-productive. Research data from classroom training and

comparisons of other organizations, both civilian and military, suggest that the discipline inherent to an ISO 9000 QMS can more effectively bring about continuous improvement in QM in Naval aviation maintenance. In turn, an ISO 9000 QMS focused on continuous improvement would help reduce quality-related incidences in Naval aviation.

The keys to implementing the ISO 9000 QMS are to: (1) have the ongoing involvement of management, especially squadron COs and MOs, (2) have proactive process management and control, (3) have the support of a basic infrastructure, and (4) to foster continual system improvement. Because a piecemeal approach toward implementing the ISO 9000 QMS is almost a certain guarantee of failure, squadrons must understand the importance of QM-related topics to the effectiveness of their QMS. These topics include QA, QC, QM documentation, QM training, and others. Selecting the appropriate QMS and deciding how it should be implemented are the key starting points to achieving superior quality performance. Each organization must decide which combination of attributes described within these topics can be used to build a QMS that best suits the needs of the Naval aviation fleet/organization. The most successful companies design their own pathways and timelines for implementing selected models.

Implementing the ISO 9000 QMS is no simple task. The breadth of activities and the number of research aspects that must be evaluated to fully change a QMS is immense. The first task in conducting this research, then, is to pick a logical starting point and establish a basis upon which further research can be conducted. That logical starting point is to describe how and why the NAMP QMS should be changed to make it more consistent with the ISO 9000 QMS and to discuss the impacts of making those changes.

A QMS is made up of processes like QM documentation, QM training, QC, QA, SPC, and others, that define how the organization functions. By identifying the primary processes that are pertinent to the NAMP and ISO 9000 QMSs, formulating process maps, and discussing the advantages and disadvantages of each of the primary process maps, the impacts of "passing ISO 9000 through the NAMP" become apparent. Knowing these impacts helps aviation Officers and Chiefs, particularly in the Navy, accurately assess the feasibility of implementing the ISO 9000 QMS.

This thesis presented four areas of research into the NAMP and ISO 9000 QMSs. First, it examined the similarities and differences between the NAMP and ISO 9000 QMSs. Second, it described the difference between the discipline in managing quality under ISO 9000 and the discipline in managing quality under the NAMP. Third, it discussed which sections in the NAMP could be changed to make them consistent with the ISO 9000 QMS. Finally, it explained the impacts, positive and negative, and benefits of making the NAMP more consistent with ISO 9000. Impacts centered around implementation issues and performance metrics for QM processes, training, documentation, and benefits.

B. CONCLUSIONS

1. Given a robust quality environment where the QMS has been thoroughly aligned with the entire organization's goals and objectives, a QMS drives process and product within that environment. However, within the Navy, the NAMP QMS is driven by the environment due to its unique operational needs and

requirements. There are endogenous and exogenous factors that currently work against a totally aligned QMS within the Naval environment.

2. **The ISO 9000 QMS must be adopted in Naval aviation organizational maintenance to help it provide logistical support in a more cost-effective manner.** If the cost of operating Naval aviation activities continues to escalate, the Navy may not be able to modernize its fleet and may not be able to adequately maintain existing assets. Also, inefficient maintenance could adversely impact the Navy's ability to meet worldwide operation commitments and contingencies. If Naval aviation has too few aircraft to support key military missions, then these missions may be taken away and given to other components DoD, and the future of Naval aviation could be threatened.

3. **The annual total number of Class "A" aircraft mishaps and TFOAs has been relatively stable for at least 10 years.** These data suggest that the ability of Naval aviation maintenance to improve its safety record and maintenance practices has probably reached a plateau. Although aviation maintenance is just one of the factors that affect aircraft mishaps/TFOAs, significant improvements in aviation maintenance quality management systems should have a measurable and positive impact on Naval aviation safety.

4. **The single most important element of any QMS is management's responsibility throughout the system, to be actively involved in building and supporting that QMS.** The consistency and intensity of management's involvement in process improvement directly correlates to how well and how quickly improved processes can be implemented. COs and MOs must demonstrate personal leadership and

involvement in creating and sustaining a customer focus and clear and visible quality values. They must instill these high standards and values into the organization's QMS. They must also support a rigorous QM training plan that gives Airmen and POs: (1) the skills they need to do their job properly and (2) the skills they need to ensure that they build quality into their maintenance techniques. It is clearly understood that meeting operation commitments takes precedence over routine requirements and mission. However, COs and MOs should be aware of the inverse impact poor maintenance and inadequate maintenance training have on a system's operational availability. Therefore, COs and MOs should place renewed emphasis on QM training and should de-conflict operational and QM training requirements to the maximum extent that is practical.

5. Naval aviation Officers and Chiefs must strive to build a properly balanced QMS that is efficacious in bringing about continuous improvement. A properly balanced QMS consists of two distinct quality management (QM) processes: quality control and quality assurance. Employees cannot produce products that on the average exceed the quality of what the process is capable of producing. The process of managing quality must be a balanced between the use of QC and QA techniques. QC is the operational techniques and activities an organization uses to ensure its product or service conforms to the organization's established quality standards. QC ensures conformity specifications are met through inspection and test functions after a good or service has been produced. QC, therefore, relies upon oversight to help manage quality. QA includes all the planned and systematic activities implemented within a QMS. They provide adequate confidence that aircraft maintenance/a product or service

will conform to the organization's quality standards. In other words, it is the process of educating Airmen and POs in how to ensure a quality good or service is produced. It gives personnel insight into building quality into a process.

6. **For three reasons, it is feasible to adopt the ISO 9000 QMS in Naval aviation organizational maintenance and to make the NAMP more consistent with ISO 9000 standards.** First, the ISO 9000 QMS is a quality standard rather than a product standard. It does not focus on products or services. It applies to the process that creates them. ISO 9000 is designed and intended to apply to virtually any product or service made by any process anywhere in the world. Second, ISO 9000 standards are non-specific in the sense that they do not mandate particular methods, practices, and techniques. They focus on one objective—meeting the customer's expectations and requirements—and are the key to building a world-class QMS. They give insight, not just oversight, into producing a quality product or service. Third, all maintenance operations operate similarly. A maintenance requirement is established, and then it must be addressed by Airmen and POs and must have a level of record keeping that is consistent with the maintenance that is being performed. Naval aviation organizational maintenance is a maintenance operation that is specialized around maintaining military aircraft. However, regardless of the complexity of the maintenance operation being performed, ISO 9000 standards are sufficiently flexible to accommodate the needs of various maintenance activities.

7. **ISO 9000 QMSs are built upon a discipline different than that upon which the NAMP QMS was built.** This discipline centers around three core values.

First, every employee's ideas and opinions are important. The opinions and ideas of the employees at the lowest levels in an organization are particularly important to bringing about continuous improvement. Employees at the lowest levels of an organization are the most intimately familiar with an organization's processes and are, therefore, in the best position to assess how to improve those processes. Also, they are best able to prevent quality problems during the production of a product or service. Furthermore, because it is easier to ingrain new processes into new employees, employees at the lowest levels can effect process improvements more readily than more experienced employees who are biased toward old operating methods and procedures. The ISO 9000 QMS relies upon trusting educated and well-trained employees to understand when a process is not producing quality products or services and empowering them to effect change to that process. Second, personnel cannot assume that an organization's processes are the best they could be. That an organization's processes have remained in place without change for a relatively long time is not reason enough to assume those processes cannot be improved. Instead, personnel must continuously improve processes. They must systematically track every process deficiency back to its ultimate cause and devise a process improvement that ensures the deficiency never occurs again. Third, every employee must be empowered to practice discretion in knowing the best way to complete tasking and trusted to be accountable in performing duties. It is particularly important to do these two things at the lowest levels of an organization because they help create an environment of openness to provide feedback on process effectiveness. This discipline inherent to the ISO 9000 QMS is different than the discipline inherent to the NAMP

QMS. Officers and Chiefs assume that Naval aviation maintenance's technicians at the lowest level are not capable of practicing discretion in knowing the best way to complete tasking and cannot be trusted to be accountable for performing duties. These managers, therefore, build these assumptions into the NAMP.

8. The ISO 9000 QMS can benefit squadrons. First, organizational maintenance activities that implement ISO 9000 should focus on quality and self-improvement. Those that do may experience:

1. Improved quality in aircraft maintenance;
2. Decreased cycle time and man-hours needed to repair aircraft, aviation components, and related support equipment;
3. Reduced product rework;
4. Improved productivity of aviation technicians and managers;
5. Improved employee morale; and
6. Improved training of aviation maintenance technicians and managers.

Secondary benefits include a reduction in the need for spare parts and supplies, a reduction in the levels of management needed, an increase in system operational availability, and an improved safety record.

Second, with an ISO 9000 QMS in place, organizational maintenance activities can function using QM processes: (1) that are unified across Naval aviation organizational maintenance, (2) that still allow for unique, (3) that are unified between departmental functions such as Maintenance, Administration, and Operations, (4) and that

set goals and objectives that are interrelated between maintenance activities and between departmental functions within those activities.

Third, although the number of audits that are performed may increase, both externally and/or internally, the comprehensiveness and effectiveness of all these audits will improve. Additionally, because ISO 9000 auditors are performing process audits, the audits performed by an AMMT can take on a new focus. It can focus less on investigating how well maintenance activities comply with the NAMP and more on sharing best maintenance processes between activities.

9. ISO 9000 is not a panacea. ISO 9000 standards do not guarantee a successful QMS for two reasons. First, ISO 9000 compliant organizations can perform poorly if the employees do not have integrity. The ISO 9000 QMS requires a level of discipline, and if Airmen and POs take shortcuts, then the ISO 9000 QMS breaks down. Second, ISO 9000 standards do not discriminate between outcomes. ISO 9000 standards are built on the underlying assumption that the economic market in which an organization does business will form a feedback mechanism. This feedback mechanism is used by organizations to assess the level of quality in the organization's product or service. The feedback mechanism is that if the product or service is not satisfying the customer, the customer can take his/her business elsewhere. Although organizational maintenance activities have customers such as aviators and others, these customers are captive. They cannot simply take their business to another organizational maintenance activity. The result of having captive customers is that the market feedback mechanism in Naval aviation organizational maintenance is significantly diluted.

10. If Naval aviation Officers and Chiefs attempt to build only some of the elements of the ISO 9000 QMS into the NAMP, the results from the implementation process may be disappointing. TQM/TQL has been largely abandoned in many activities in the Navy. The implementation of TQM/TQL in the Navy brought about little real change because the Navy adopted only some of the elements of the TQM/TQL system. This same argument can be made about how the ISO 9000 QMS should be implemented because the ISO 9000 QMS and TQM/TQL are parallel systems that are founded on the same principles, Dr. Deming's 14 Points for implementing quality improvement (see Appendix A). Also, one of the driving forces behind commercial organizations becoming ISO 9000 registered is that their customers require it. There is no such driving force compelling squadrons to become ISO 9000 registered. If squadrons are not formally required to become ISO 9000 registered, they will not be disciplined in their approach to the implementation of the ISO 9000 QMS. If they do not take this disciplined approach, they may be tempted to adopt only some or none of the parts of the ISO 9000 QMS. However, the ISO 9000 QMS must be adopted in its entirety or it will be ineffective.

11. The organizational maintenance aspects of the QMS within the NAMP are not currently consistent with the ISO 9000 standards.

(1) The NAMP does not currently describe the roles and responsibilities that must be assigned for the three elements of change implementation: the initiating sponsor, the change agent, and the change target. Nor does it describe an implementation process for adopting the ISO 9000 QMS and achieving continuous improvement.

(2) Elements of the QMS within the NAMP are not grouped into a quality manual as a total system, but are discussed in different sections throughout the NAMP. This has the effect of fractionalizing the responsibilities and roles in the NAMP's QMS. Airmen and POs, therefore, fail to understand the systemic nature of the NAMP's QMS and view it only as isolated requirements.

(3) The NAMP QMS does not address all of the ISO 9000 clauses including management responsibilities, process controls, and statistical techniques.

(4) The NAMP QMS is largely biased toward achieving QM through QC procedures, with little emphasis on QA procedures.

(5) The NAMP currently assigns the data analyst at organizational maintenance activities resides to the Maintenance Administration Division, not the Quality Assurance Division. This further inhibits the effective use of trend analysis and SPC because there is less collaboration between the data analyst and other QM POs. There was previously a significant level of collaboration to use trend analysis and SPC to uncover QM problems when the data analyst was assigned to the QA division. With the data analyst assigned to Maintenance Administration, the level of understanding of other QM POs about trend analysis and SPC suffers. The data analyst is the person with the most training in these techniques.

(6) The NAMP currently promulgates policy and procedures for both the organizational and intermediate levels of maintenance concurrently. The maintenance management policies and procedures for each level of maintenance are not separated into different volumes which leads to confusion and wasted time when searching for

information. If the ISO 9000 QMS is instituted in Naval organizational maintenance activities, but not the intermediate maintenance activities, then the NAMP must separate the policies and procedures for two different QMSs, the ISO 9000 QMS for the organizational maintenance activities and the current NAMP QMS for intermediate maintenance activities.

(7) The NAMP does not promote continuous improvement in Naval aviation organizational maintenance. Airmen and POs cannot assume processes are the best they can be just because "that is the way we have always done it."

(8) The NAMP does not require Officers and Chiefs in Naval aviation organizational maintenance to construct a complete process flowchart. This flowchart would show the flowdown of maintenance management requirements from the NAMP down to the local SOPs. It would help raise the awareness of Airmen and POs of the requirements to which their maintenance techniques must comply and help them see the system of requirements that form the basis for maintenance processes.

(9) The NAMPSOPSs in Volume V of the NAMP do not fully embrace the format required by the ISO 9000 standards. While much of the format characteristic to the NAMPSOPs is already consistent with the ISO 9000 format, changes must be made that will create a process focus within the NAMPSOPs, instead of a program focus.

(10) The NAMP does not currently require that Airmen and POs have access to a database of discrepancies to assist with troubleshooting procedures. It is therefore difficult to perform trend analysis to draw conclusions about quality problems in aircraft maintenance and harder to troubleshoot maintenance discrepancies. Denying QM and

maintenance personnel access to this invaluable QM tool makes it harder for them to perform their job more effectively.

(11) The current process for recommending and submitting changes and corrections to maintenance-related instructions and publications that is built into the NAMP is not effective. The current process is cumbersome and fragmented, and it provides an inadequate means of sending feedback to those submitting the changes. It is not supported by adequate engineering expertise to ensure timely responses to change requests, and the engineering expertise that is available lacks a practical understanding of the system repairs that are in question.

(12) The NAMP does not clearly discuss the importance of Officers and Chiefs being committed to building effective QMSs by manning the QA Division with the most competent QM representatives.

(13) The NAMP does not require squadrons to be formally registered. Being formally required to become ISO 9000 registered will force squadrons to be disciplined in their approach to the implementation of the ISO 9000 QMS. If they do not take this disciplined approach, they may be tempted to adopt only some or none of the parts of the ISO 9000 QMS.

(14) The NAMP does not clearly describe the responsibility Officers and Chiefs in Naval aviation organizational maintenance, particularly squadron COs and MOs, have to demonstrate personal leadership and involvement in creating and sustaining a customer focus with clear and visible quality values. They must integrate these values into their squadrons' QMSs. The single most important element of any QMS is management's

responsibility to and active involvement in building and supporting that QMS. The consistency and intensity of management's involvement in process improvement directly correlates to how well and how quickly improved processes can be implemented.

(15) The NAMP does not clearly mandate the responsibilities that Officers and Chiefs have to ensure that MIMs are used and followed, and that Airmen and POs must display integrity in ensuring they are used. MIMs are the foundation to QA in squadrons. They are the first tool available to maintenance technicians to ensure QA is employed.

12. QM training in organizational maintenance does not focus on process control and problem-solving techniques. Maintenance technicians/QM auditors in Naval aviation organizational maintenance are not trained to use methodologies similar to Toyota's "five whys" exercise to systematically track every process deficiency back to its ultimate cause and devise a process improvement that ensures that the deficiency never occurs again. Maintenance technicians must always evaluate what processes are being performed and whether they are adding value to the organization's output. Also, training of QM POs in Naval aviation organizational maintenance is deficient in two ways. First, formal QM PO training consists only of familiarizing them with the elements of programs they will audit. They are not formally taught proper auditing techniques. Instead, they must learn these techniques through on-the-job training and by pass-down from person to person. Second, QM POs at the organizational maintenance level receive no formal training in trend analysis and SPC methods. This makes it difficult for these personnel to investigate problematic trends in QM. Furthermore, the NAMP does not mandate the use

of training feedback loops to improve training effectiveness. If they are not properly trained to do their job, they cannot build quality into their maintenance practices.

13. The QA training within the NAMP's QMS lacks critical elements thus rendering the QMS ineffective in managing quality in aircraft maintenance. Mandating certain training and data access will help inculcate maintenance and QM POs and Officers and Chiefs with the ability to build quality into aircraft maintenance. First, not all Naval aviation Airmen and POs attend basic aircraft maintenance at "A" school. If Airmen and POs do not attend this basic maintenance training, variability is introduced in the theoretical understanding of Airmen and POs from person to person. Variability in the theoretical understanding from maintenance personnel to maintenance personnel results in variability of the ability to build quality into a product from maintenance personnel to maintenance personnel. Second, when FRAMP was eliminated, technician expertise suffered. Technician expertise can neither be supplanted in MIMs nor taught in the classroom environment. Also, "A" school, "C" school and NAMTRA do not provide "heat-of-the-moment" training. Additionally, NAMTRAGRUDETs are limited in what types of discrepancies they can reproduce. They generally have access only to static aircraft, not operational aircraft that have real-world discrepancies such as structural overstresses resulting from hard landings. This type of practical, real-world training is needed by maintenance personnel to build intuitive understanding of maintenance processes and techniques. Third, ethics training is not included in the curricula taught at the "A" school, "C" school, and NAMTRAGRU. Ethics training allows Airmen and POs to discuss the consequences of their actions when they fail to build quality into their

maintenance techniques. Having this training reinforces the sense of obligation Airmen and POs feel to perform maintenance procedures and processes correctly the first time, every time. Fourth, Officers and Chiefs fail to understand the importance of supporting a maintenance activity's QA training effort. It takes leadership, particularly from work center supervisors, to help Naval aviation maintenance's young maintenance technicians realize the importance of practicing integrity when accomplishing aircraft maintenance. Fifth, QM auditors under the NAMP are not taught how to properly audit, only what to audit. Auditor training teaches QM auditors how to intuitively find aspects of processes that perform less than optimally. QM POs in squadrons currently learn what to audit from other QM POs. Because this training is based largely upon passdown from QM representative to QM representative, there is variability in the depth and comprehensiveness of the training in auditing received by each QM representative. Sixth, OJT and PQS training for performing maintenance processes is not standardized. Standardization of OJT/PQS training reduces the variability introduced in the depth and comprehensiveness of the training received by Airmen and POs. Airmen and POs must receive a minimum level of training to ensure maintenance processes and techniques are performed the same from technician to technician. This ensures quality is built into these maintenance practices and processes. Seventh, there is little refresher training for organizational maintenance activities. The training that is conducted may not focus on recurring problem areas or skill deficiencies. Refresher training ensures that organizational maintenance activities retain a minimum core of maintenance skills despite the rapid turnover of personnel.

14. Data concerning QM problems in Naval aviation organizational maintenance is currently being collected through the MDS and through the flight mishap/incident tracking system, but it is not currently categorized into meaningful metrics that highlight these problems. Organizational maintenance activities already perform the NAMP-required categorization of data that is related to QM problems, but this is scant and not very revealing of QM problems. Additionally, Airmen and POs are not trained in how to group these data into meaningful metrics or perform trend analysis on the data. These data are, therefore, simply not categorized at the organizational maintenance level into meaningful metrics from which conclusions about quality problems can be drawn. Also, the aviation mishaps and incidences caused by quality problems are separated into various categories including mishaps caused by material failures and maintenance malpractice, and mishaps caused by human factors. Aviation mishaps and incidences caused by quality problems are not tracked separately. Both the separate categories for mishaps caused by material failures and maintenance malpractice and mishaps caused by human factors do not separate mishaps where poor quality management is involved from mishaps where it is not.

15. The practice of sending Airmen and POs newly assigned to aviation maintenance activities TAD for six (6) months or more working outside their rating is detrimental to their effectively practicing QA. Airmen and POs lose training over time. Every month that a person spends away from the job s/he was assigned to do, that person loses, at least temporarily, some of that training. They either never recoup this learning or must spend at least six (6) months trying to refamiliarize themselves with the

work they were trained to do. Also, the practice of sending Airmen and POs TAD tends to cause a person's interest to wane in the work they were trained to perform. Because the interest a person has in his or her work parallels the interest that that person has in ensuring that they produce quality products or services, disinterest in work parallels disinterest in QA.

C. RECOMMENDATIONS

This section discusses the recommendations developed from the research effort. The recommendations are grouped into the following four categories: (1) adoption of ISO 9000, (2) revision of NAMP organizational maintenance sections, (3) incorporation of performance metrics, and (4) changing current training philosophies, practices, and processes.

1. International Standards Organization 9000

a. NAVAIR should Adopt the ISO 9000 QMS in Squadrons.

(1) The NAMP must clearly discuss the importance of the ISO 9000 QMS to improving QM within Naval aviation organizational maintenance. In an era of fiscal restraint, if the cost of operating Naval aviation activities continues to escalate, the Navy will be able to buy and maintain fewer aircraft. Also, if aviation maintenance activities are performing maintenance less than optimally, the trend will be for more aircraft to be down for maintenance making fewer aircraft available to support operational commitments around the world.

(2) Officers and Chiefs in Naval aviation organizational maintenance must adopt the ISO 9000 QMS in its entirety or not at all. They should not attempt to implement some

of the elements of the ISO 9000 QMS and disregard others. The primary benefits to Naval aviation maintenance of adopting the ISO 9000 QMS are improved quality of aircraft maintenance, decreased cycle time in the completion of aircraft maintenance, reduced maintenance due to fewer repeat discrepancies, improved productivity of Airmen and POs, and improved training of Airmen and POs, and an enhanced safety record in Naval aviation. Secondary benefits include a reduction in the cost of providing maintenance support to aircraft due to a reduction in the need for spare parts and supplies, a reduction in the levels of management needed, an increase in system operational availability, and an improved Naval aviation safety record.

(3) A stance toward formal ISO 9000 registration should be adopted by NAVAIR. Formalizing the ISO 9000 registration process forces squadrons to take a disciplined approach toward implementing the ISO 9000 QMS.

b. Consistency is Needed between Organizational Maintenance Sections of the NAMP and ISO 9000 Standards.

(1) The writing system or tone, of the NAMP must be changed for the sections that deal with organizational maintenance to help Officers and Chiefs in Naval aviation generally think more in terms of the Generative Configuration and to help reshape the currently prevailing culture in organizational maintenance. It must support the ISO 9000 QMS which has elements that are characteristic of a Generative Configuration.

(2) The doctrine structure of organizational aspects of key parts of these sections of the NAMP QMS should be converted to the ISO 9000 structure. Volume V of the NAMP should be converted into the quality manual for Naval aviation organizational maintenance because this is the part of the NAMP that standardizes maintenance programs and forms a logical basis for building Level 1 of the ISO 9000 structure. All quality procedures should be grouped into a second level. The third level should consist of quality work instructions. The fourth level should be comprised of

records and forms. Grouping the quality procedures, quality work instructions, and records and forms into Levels 2, 3, and 4, respectively, helps maintenance personnel understand the flow-down of policies and procedures contained within each of these levels. Personnel are better able to make the logical connection of the maintenance policies and procedures in one level to those in the next level. They become more aware of these policies and procedures and the overall objectives of these policies and procedures at any given level. Because they understand these policies and procedures better, they are more likely to internalize them. The result of this internalization is that Airmen and POs come to see the need for the policies and procedures and; therefore, will better support them. This ensures that current and future maintenance policies and procedures will be more efficacious in producing quality maintenance.

(3) The NAMP must reassign the DA to the QA Division in squadrons and not to the Maintenance Administration Division. This promotes better understanding and collaborative use of trend analysis and SPC.

(4) The NAMP must assign and describe the roles and responsibilities that must be assigned for elements of change implementation: the initiating sponsor and the change target. These elements are critical to the successful implementation of change. Without them the probability of successfully implementing change is reduced.

(5) The NAMP must describe and assign responsibilities for the six-step implementation process for adopting the ISO 9000 QMS and the timeless process of achieving continuous improvement. These six steps include: (1) assessment, (2) planning, (3) upgrading, (4) implementation, (5) auditing, and (6) continuous improvement. The NAMP currently requires Airmen and POs to continuously improve maintenance processes, but it offers no prescriptive methodology for achieving continuous improvement. Establishment of this six-step implementation plan forces Naval aviation organizational maintenance managers to take a disciplined approach to achieving continuous improvement in maintenance

processes. This disciplined approach will enhance Naval aviation organizational maintenance's ability to identify better maintenance processes that can reduce wastes such as rework and unwarranted long repair cycle times and lower the cost of supporting aircraft.

(6) The NAMP must either separate those activities unique to the organizational level of maintenance from intermediate activities in Volume I of the NAMP or embrace ISO 9000 at both the organizational and intermediate levels of maintenance. If it does neither, two separate QMSs will exist within the NAMP and create confusion among Airmen and POs and inconsistencies in the operation of the QMS.

(7) The NAMP must capture and promote the essence of continuous improvement in Naval aviation organizational maintenance. The essence of continuous process improvement is that Airmen and POs must continually ask themselves whether the current processes are the best they can be. This is having insight into the efficaciousness of processes to produce quality products and services. If Airmen and POs do not understand and practice this concept, they will not have the ability to bring about the continuous process improvement that is critical to the effectiveness of a QMS. Alignment of incentives also need to be addressed.

(8) The NAMP must require Officers and Chiefs in Naval aviation organizational maintenance to construct the ISO 9000 process flowchart. This flowchart must show the flowdown of maintenance management requirements from the NAMP down to the local SOPs. This chart must be constructed for two reasons. First, it is a requirement for becoming ISO 9000 registered. Second, it helps raise the awareness of Airmen and POs of the requirements to which their maintenance techniques must comply and help them see the system of requirements that form the basis for maintenance processes, thus this helps bring about QA.

(9) The NAMPSOPs in Volume V of the NAMP must be modified to make them consistent with the ISO 9000 standards. They must address the clauses of the ISO 9000

standards, and must show a logical process flow that is consistent with how processes are performed in real-world operations. Some of the changes will include reassigning a process to a process manager instead of a program manager, eliminating duplicate and/or unnecessary processes, constructing a process flowchart that allows Airmen and POs to visually see the process flow. In addition to being a requirement of implementing the ISO 9000 QMS, theses changes help ensure Airmen and POs will consistently use the NAMPSOPs.

(10) The NAMP must require that Airmen and POs have access to databases of discrepancies to assist with troubleshooting procedures. Such a database will facilitate the performance of trend analysis from which to draw conclusions about quality problems in aircraft maintenance. It will also facilitate troubleshooting maintenance discrepancies as Airmen and POs are able to readily retrieve information on similar discrepancies.

(11) A more effective process for recommending and submitting changes and corrections to maintenance-related instructions and publications must be built into the NAMP. The current process is cumbersome and fragmented, and it provides an inadequate means of sending feedback to those submitting the changes. Also, it is not supported by adequate engineering expertise to ensure timely responses to change requests, and the engineering expertise that is available lacks a practical understanding of the system repairs that are in question. Additionally, the format for submitting such changes must be better designed. The current format is time-consuming and difficult to use. Improving this format would ensure that Airmen and POs are more likely to make the effort to submit process changes that could improve the quality of aircraft maintenance. Furthermore, the NAMP must require a more efficient system for sharing information about discrepancies between reporting activities and with Airmen and POs. If maintenance activities and their personnel have access to such information they can use it to assist in troubleshooting procedures and improve the quality of their maintenance techniques.

(12) The role AMMTs play in bringing about continuous process improvement must be expanded. In this expanded role, AMMTs should travel to commercial maintenance organizations to observe the best maintenance practices being used at organizations such as United Airlines. Commercial maintenance organizations are driven to improve their processes based on market response from customers. Although this kind of feedback mechanism is absent in Government entities like squadrons, it can be artificially captured when best practices are brought from commercial industry to Government activities. AMMTs can serve as the bridge between the market feedback mechanism found in commercial aviation maintenance activities and the non-commercially driven operating environment found in squadrons.

2. Performance Metrics

a. *Improved Performance Metrics are Required that Highlight Quality Problems in Squadrons.*

(1) Maintenance data that highlights quality problems should be collected at two levels: (1) at the Naval Safety Center for flight mishaps and incidents caused by quality management problems and (2) in organizational maintenance activities to identify repeat and other maintenance discrepancies stemming from QM problems. Organizational maintenance activities already perform some categorization of data that is related to QM problems, but this is scant and not very revealing of QM problems. The NAMP should describe and formalize what data should be collected to create the best metrics for analyzing QM problems. Examples include SPC charts like those used by United Airlines and discussed in Chapter V, the top five maintenance reliability issues, the number of aeronautical removals per 1000 flight hours, the number of in-flight discrepancies per 1000 flight hours, the number of repeat discrepancies per 1000 flight hours, the ratio of unscheduled to scheduled maintenance actions, and MTTR plotted against the number of hours required by the MIMs to perform maintenance actions.

b. Improved Performance Metrics are Required that Highlight QM Training Problems in Squadrons.

(1) The NAMP must require the monitoring of QM training to allow Officers and Chiefs to assess how effective this training is. This can be accomplished through the inclusion of QM-related questions on rating exams. These questions might test an individual's ability to recognize when maintenance actions are caused by QM problems, not technical problems. Another method to monitor QM training is to include QM qualification elements on PQSs.

(2) Training performance metrics should be tied to training feedback loops. This will allow Airmen and POs to state how effective the training they receive is in: (1) giving them the skills they need to do their job properly and (2) giving them the skills the need to ensure they build quality into their maintenance techniques. This information can then be fed back to improve training courses.

3. Training

a. A Revised Training System is Needed in Organizational Maintenance.

(1) The organizational maintenance sections of the NAMP must address training in QA, not just QC. All Airmen and POs in Naval aviation organizational maintenance must receive training in how to ensure quality is built into a product or service. Formal ethics training should be conducted at the NAMTRAGRUDETs. This allows Airmen and POs to understand that they may contribute to aviation mishaps and incidences by failing to ensure their actions build quality into aircraft maintenance. As a result, they come to understand the consequences of their actions. Also, the FRAMP program must be re-instituted with a formalized syllabus to standardized training. Because FRAMP is a practical on-the-job (OJT) type of training, it allows the theories that are studied in the maintenance training classrooms to be consummated with real-world maintenance scenarios. This consummation helps Airmen

and POs build their intuitive understanding of aircraft maintenance thereby enhancing their ability to build quality into aircraft maintenance.

(2) The organizational maintenance sections of the NAMP must address training in trend analysis and SPC. QM POs in Naval aviation organizational maintenance must receive better QM training. First, they be must trained on how to audit, not just *what* to audit. Second, they must be formally trained in how to use trend analysis and SPC. Having these two skills gives QM POs a better intuitive sense of knowing when the program they are auditing is not optimally effective and of identifying the root of why the program is not optimally effective. Overall, QM audits become more thorough and more efficacious in bringing about continuous process improvement.

(3) The organizational maintenance sections of the NAMP must address how to achieve continuous process improvement in squadrons. All Airmen and POs must receive training in how to achieve continuous process improvement. This training should center around the use of a methodology similar to Toyota's "five whys" exercise. This training will give Airmen and POs insight into how to ensure they produce quality maintenance. Higher quality maintenance leads to less rework, and less rework leads to less down time for aircraft. Higher quality maintenance also leads to an improved safety record because Airmen and POs consciously self-evaluate their work. They ensure that the maintenance techniques they use are: (1) absolutely compliant with all established maintenance policies and procedures and (2) the best way to conduct maintenance.

(4) The NAMP must establish training feedback loops that allow the effectiveness of training to evaluated. Training can then be modified to ensure it inculcates Airmen and POs with the skills they need to do their job properly. If Airmen and POs are properly trained to do their job, they can do it correctly the first time, every time. They are able to ensure they build quality into their maintenance techniques.

b. ***The practice of sending Airmen and POs newly assigned to organizational maintenance activities to a temporary assignment for six (6) months or more should be dropped.***

(1) Time spent TAD performing work that does not utilize the training Airmen and POs have been given wastes that training. Every month that a person spends away from the job s/he was assigned to do, that person loses, at least temporarily, some of that learning. They either never recoup this training or must spend at least six (6) months trying to refamiliarize themselves with the work they were trained to do.

(2) Airmen and POs straight out of "A" and "C" schools are generally interested in the areas of expertise in which they have been trained. Because they are interested in what they have studied further training in the form of OJT is enhanced. They learn more about their area of expertise faster and with more retention. TAD assignments cause Airmen and POs to lose interest in studying their areas of expertise, and then Officers and Chiefs face a daunting task in attempting to regain that interest.

4. Culture

a. ***NAVAIR Must Promote Cultural Change within Naval Aviation Organizational Maintenance.***

(1) Airmen and POs cannot continue to perform maintenance based on the "that-is-the-way-we-have-always-done-it" mentality. This promotes stagnation in maintenance processes and will make the ISO 9000 QMS implementation process unsuccessful.

(2) Officers and Chiefs must think in configurational terms as discussed in Chapter II. They must change the culture that currently prevails in Naval aviation, a culture that is characteristic of the Directive Configuration. The changed culture that emerges must foster continuous improvement and empower Airmen and POs at any level or rank to

actively contribute to achieving this improvement. These are elements that are characteristic of a Generative Configuration.

b. ***The NAMP must describe the responsibilities that squadron COs and MOs in Naval aviation organizational maintenance have to demonstrate in terms of personal leadership and involvement in creating an effective QMS.***

(1) Officers and Chiefs in squadrons must create and sustain a customer focus with clear and visible quality values and require the integration of these quality values into the organization's QMS. The single most important element of any QMS is management's responsibility to and active involvement in building and supporting that QMS. The consistency and intensity of management's involvement in process improvement directly correlates to how well and how quickly improved processes can be implemented. Airmen and POs cannot perform maintenance that, on the average, exceeds the quality of the maintenance processes that are being used to perform aircraft maintenance.

(2) Officers and Chiefs must support the building of a QMS that is balanced in its use of QC and QC techniques. An effective QMS is properly balanced in its incorporation both aspects of managing quality—QC and QA. This ensures that quality is built into aircraft maintenance as it is being performed. Relying solely on QC techniques to manage quality is inefficient and costly.

(3) Officers and Chiefs must support a rigorous QM training plan that gives Airmen and POs (1) the skills they to do their job properly and (2) the skills they need to ensure they build quality into their maintenance techniques. Officers and Chiefs cannot allow support of operational commitments to take priority over this training. Airmen and POs cannot build quality into their maintenance techniques if they do not have the theoretical and intuitive, or practical understanding of the maintenance processes they are expected to perform.

(4) Officers and Chiefs must be committed to building effective QMSs by manning the QA Division with the most competent QM representatives. QM processes cannot be efficacious at ensuring quality is built into aircraft maintenance or in bringing about continuous process improvement without the involvement of well-trained, competent QM POs.

(5) Officers and Chiefs must ensure compliance with MIMs. MIMs are the foundation to QA in squadrons. They are the first tool available to maintenance technicians to ensure QA is employed.

D. RECOMMENDATIONS FOR FURTHER STUDY

Implementing the ISO 9000 QMS is not simple. The depth and scope of activities that must be studied in order for ISO 9000 QMS to be adopted in Naval aviation maintenance is substantial, yet achievable. This thesis focuses only on one aspect of implementing the ISO 9000 QMS: changes that must be made to the NAMP in order for it to be consistent with ISO 9000 standards. There are six additional aspects that require further research.

1. A plan for implementing the ISO 9000 QMS in Naval aviation's organizational maintenance activities must be developed. This plan should discuss the specific activities and intermediate steps that should take place while ISO 9000 is being implemented. Next, it must address how the organizational configuration should be modified to reflect the culture/paradigm needed to ensure the ISO 9000 QMS is effectively implemented. Then it must identify who will perform the internal and external audits, develop a timeline for completing the audits, and assign responsibilities for conducting the audits. Additionally, it might address the possible development of a

classification system for QM billets that ensures a permanent pool of well-trained, experienced QM POs is available from which QM billets at organizational maintenance activities can be filled. Furthermore, there are endogenous and exogenous factors that currently work against a totally aligned QMS within the Naval environment. These factors will also work against the ISO 9000 QMS and must be studied in detail before an ISO 9000 QMS can be effectively implemented. Finally, the plan should detail how continuous improvement can be achieved in Naval organizational maintenance.

2. Performance metrics must be developed to measure the effectiveness and efficiency of the ISO 9000 QMS in squadrons. These metrics should help activities isolate quality problems in their processes and bring about continuous process improvement. Separate metrics should be developed to track aviation mishaps and incidences caused by quality problems such as TFOAs caused by an improperly fastened aircraft panel. There should also be better metrics developed to track rework actions, maintenance actions resulting from the initial installation of poor quality material or the practice of poor quality maintenance techniques. Finally, metrics that clearly identify quality problems stemming from poor training must be developed. Developing these metrics for organizational maintenance activities is difficult because even commercial aviation maintenance activities like United Airlines have not fully developed appropriate metrics. They are only beginning to develop the full range of metrics needed. This thesis topic would require extensive research at many different ISO 9000 activities, both commercial and military, to develop the necessary range of metrics needed to adequately monitor the performance of the ISO 9000 QMS.

3. The same aspects of the ISO 9000 QMS that are studied for organizational maintenance activities must also be studied for intermediate maintenance activities. These aspects include changes to the sections of the NAMP that concern Naval aviation intermediate maintenance, the development of performance metrics for the ISO 9000 QMS at the intermediate level, and a plan for implementing the ISO 9000 QMS in intermediate maintenance activities.

4. Organizations that fail an ISO 9000 QMS implementation process must be studied to gain insight into the underlying reasons that cause failure. This research would provide invaluable lessons learned for squadrons as they implement the ISO 9000 QMS. They would be able to shape their implementation process to address and eliminate theses causes for failure.

5. Research must be conducted to develop the tenets in a hypothetical ISO 9000 quality manual for squadrons. This research should assess how the 20 clauses in Appendix B can be satisfied by this quality manual. It should also assess how the QA-managed and –monitored programs in the NAMP would fit into this manual. Each of the NAMPSOP covering a QA-managed or –monitored programs should be assessed for ISO 9000 compliance. Recommendations for changes to these NAMPSOPs should be made.

6. Research must be conducted to help Naval aviation maintenance more readily determine what is the ratio of unscheduled to scheduled maintenance for Naval aviation organizational maintenance as a whole. The current methodology for obtaining this ratio is difficult and time-intensive. To do this involves extensive research with the Data Services Facility to collate data that has been collected through NALCOMIS. This

research should result in recommendations to squadrons as to a methodology for tracking and interpreting this ratio.

7. Research must be conducted into the efficaciousness of the ISO 9000 QMS to address the cannibalization problems that exist in squadron maintenance. Some of the cannibalization actions are caused by supply shortages, and some are caused poor maintenance management. Squadron Officers and Chiefs should renew their efforts to control cannibalization rates. This research must discuss how the ISO 9000 QMS will help Officers and Chiefs control cannibalization rates. It must also discuss what performance parameters can be constructed to allow Officers and Chiefs to monitor the progress of the ISO 9000 QMS in controlling cannibalization rates.

8. Post-ISO-9000-implementation squadrons must be studied to determine the efficaciousness of the ISO 9000 QMS to improve QM in organizational maintenance. This research should include an assessment of the metrics being used to monitor the performance of the ISO 9000 QMS in squadrons. It should also discuss the effectiveness of the improvements to QM training that are implemented. Finally, it should account for the impact of a high turnover of personnel who are overworked and shorthanded upon the effectiveness of the ISO 9000 QMS.

APPENDIX A. DEMING'S 14 POINTS FOR IMPLEMENTING QUALITY IMPROVEMENT [24, P 83]

1. Create consistency of purpose.

2. Lead to promote change.

3. Build quality into the product; stop depending on inspections to catch problems.

4. Build long-term relationships based on performance instead of awarding business on the basis of price.

5. Continuously improve product, quality, and service

6. Start training.

7. Emphasize leadership.

8. Drive out fear.

9. Break down barriers between departments.

10. Stop haranguing workers.

11. Support, help, and improve.

12. Remove barriers to pride in work.

13. Institute a vigorous program of education and self-improvement.

14. Put everybody in the company to work on the transformation.

APPENDIX B. INTERNATIONAL STANDARDS ORGANIZATION 9001 DESCRIPTION OF CLAUSES [34]

Appendix B briefly describes each of the 20 clauses of ISO 9001. Its purpose is to give the reader a general, rather than a comprehensive understanding of the ISO 9001 clauses.

Each clause starts with a "4." This is because the requirement clauses comprise the fourth section in each of the ISO 9000 standards. The first three sections of ISO 9000 cover scope, references, and definitions. ISO 9002 does not include clause 4.4. ISO 9003 does not include clauses 4.4, 4.6, 4.9, and 4.19. The following clauses are paraphrased from United Airlines' *Pocket Guide to the Basics: What Every Employee Needs to Know About ISO 9000.*

4.1. MANAGEMENT RESPONSIBILITY

The single most important part of any quality system is management's involvement. This sub-clause addresses management's responsibility related to: (1) developing and communicating a quality policy, (2) defining the responsibilities, authority, and interrelationship between management and/or employees whose work affects quality, (3) assigning the proper level of resources that impact quality, (4) identifying an executive who is responsible for ensuring that the quality system is established and operating properly, and (5) assigning an executive-level individual the responsibility for reviewing the quality system at defined intervals to ensure that it conforms to ISO 9001.

4.2. QUALITY SYSTEM

The organization shall implement and maintain a documented quality system that ensures a quality product. It also requires that the quality procedures be detailed enough for the type of work they describe and the skill levels of people who use them.

4.3. CONTRACT REVIEW

A contract review process must be established and implemented that covers each order, contract, or tender to ensure the product requirements are defined and documented. This procedure must also ensure the organization has the capability of meeting these requirements.

4.4. DESIGN CONTROL

The organization must have written procedures for controlling the process of designing and verifying new or changed products.

4.5. DOCUMENT AND DATA CONTROL

Control of data, documents, and information must be applied to any document and data systems that can affect quality. The document and data approval release and change cycle should be defined, documented and followed. It should ensure that obsolete documents are removed or if maintained should be identified as obsolete.

4.6. PURCHASING

This clause ensures that a system is established for selecting vendors that are responsive to customer needs and build quality into their products. It also provides

guidance for evaluating subcontractors or vendors and provides guidance on clearly describing the product ordered and includes the supporting documentation.

4.7. CONTROL OF CUSTOMER-SUPPLIED PRODUCT

The organization shall establish and maintain documented procedures for the control, verification, storage, and maintenance of customer-supplied products provided for incorporation into final products.

4.8. PRODUCT IDENTIFICATION AND TRACEABILITY

The organization shall establish and maintain procedures for identifying the product throughout its evolution and installation (receipt, production, delivery, and installation).

4.9. PROCESS CONTROL

Process control applies to processes that are involved in production, installation, and servicing that has a direct affect on quality of the item. These controlled conditions include: (1) documenting procedures where their absence could adversely affect quality, (2) monitoring and controlling process parameters, and (3) maintaining records for qualified processes, equipment, and personnel as appropriate.

4.10. INSPECTION AND TESTING

As part of the quality plan, a detailed inspection and testing plan should be defined. Records should be maintained for all inspection and test operations. This clause

requires inspection and test plans be developed for receiving, in-process, and final inspection and tests.

4.11. CONTROL OF INSPECTION, MEASURING, AND TEST EQUIPMENT

This clause requires the appropriate selection of equipment to ensure its accuracy and precision is in keeping with the product's requirements and specifications, a document control program to maintain calibration for all the related equipment, and calibration system, with accompanying records, to show calibration status is in place.

4.12. INSPECTION AND TEST STATUS

Only products that have completed the inspection and testing activities as defined in the quality plan are dispatched, used, or installed.

4.13. CONTROL OF NONCONFORMING PRODUCT

Controls shall be provided for identification, documentation, evaluation, segregation, and disposition of nonconforming products and for notification to the functions concerned.

4.14. CORRECTIVE AND PREVENTIVE ACTION

Documented procedures should be established for taking corrective action relating to complaints, nonconformity detected during process audits, and in-process fallout. These procedures should be implemented and monitored to ensure that the corrective action is effective and that it eliminates the detected problem. In addition, the organization shall analyze and eliminate potential causes of nonconformity through the

use of appropriate source information and shall implement action that deals with the potential problems before errors occur.

4.15. HANDLING, STORAGE, PACKAGING, PRESERVATION, AND DELIVERY

This clause points out the importance of proper analysis and evaluation of handling, storage, packaging, preservation, and delivery processes. It not only addresses the importance of proper controls to ensure the product is not damaged but also proper marking to ensure the product is identifiable.

4.16. CONTROL OF QUALITY RECORDS

The quality record system provides an audit trail through the production, delivery, and installation processes that verify compliance to requirements. The organization shall establish and maintain documented procedures for identification, collection, indexing, access, filing, storage, maintenance, and disposition of quality records.

4.17. INTERNAL QUALITY AUDITS

"What gets measured gets done" is one of the basic rules in management. It is therefore very important that the QMS is regularly audited to ensure its viability and applicability. The results of these quality audits should be documented and be part of a management review process.

4.18. TRAINING

This clause requires that documented procedures be established that identify training needs and provide for the training of all personnel whose performance affects the quality of the product or service. It requires that appropriate records of all training shall be maintained.

4.19. SERVICING

When servicing is a specified requirement, the organization shall establish and maintain documented procedures for performing, verifying, and reporting that the service meets the specific requirements.

4.20. STATISTICAL TECHNIQUES

The organization shall establish and maintain documented procedures to implement and control the application of statistical techniques when they are applicable. It is important for the organization to establish, control, and verify process capabilities and product characteristics.

APPENDIX C. SAMPLE COMPUTERIZED SELF-EVALUATION CHECKLIST [5]

Activity - Computerized Self Evaluation Checklist (CSEC)
08/05/1998
NATMSACT using NAVY Initial Settings
Area Checklist
Area: 200, Maintenance Training Program
Organizational Maintenance Level

NUMBER		QUESTION	Yes	No
201 C	S	Does the AMO establish and coordinate department training requirements, to include obtaining school quotas, to support training requirements? Ref. OPNAVINST 4790.2G. Vol. V. para. 2.3 d	____	____
204 C	Q	Has each Division Officer tailored the Wing Training Syllabus/MATMEP for each individual to account for past experience, training, and MTIP progress, to include at least: lectures, CBT, and OJT supplemented by required reading? Ref. OPNAVINST 4790.2G. Vol. V. para. 2.3 h(2)	N/A	
206 C	Q	Is a training record/ITSS (MATMEP) training jacket initiated for each enlisted member? Ref. OPNAVINST 4790.2G. Vol. V para. 2.3 c. e(3), 2.4 i(1) and MCO P4790.12B, appendix b. para A3a	____	____
208 C	B	Are training records/ ITSS (MATMEP) training jackets organized in the proper format? Ref. OPNAVINST 4790.2G. Vol. V. para. 2.4 i and MCO P4790.12B, app B, para B	____	____
212 C	B	Are supplemental lesson guides to support aircraft and equipment not covered by MTIP prepared in the proper format? Ref. OPNAVINST 4790.2G. Vol. V, para 2.4 g(4)	N/A	
226 C	B	Are active and standing required reading files properly established and utilized? Ref. OPNAVINST 4790.2G, Vol. V. para. 2.4 f	____	____
227 C	B	Is the active required reading file reviewed by the work center supervisor on a monthly basis to ensure material is current and all work center personnel are logging their progress on the OPNAV 4790/34? Ref. OPNAVINST 4790.2G, Vol. V, para 2.4 f(1)	____	____
228 C	S	Is MTIP administered IAW general MTIP policy and procedures? Ref. OPNAVINST 4790.2G Vol. V para. 2.3 h(1)	N/A	
238 C	S	Has the AMO been designated in writing as the Maintenance Training Officer? Ref. OPNAVINST 4790.2G. Vol. V, para. 2.3 c(1)	____	____
239 C	B	Is required training conducted on NAMP programs/processes? Ref. OPNAVINST 4790.2G. Vol. V, para. 2.4 a	____	____
240 C	B	Is required NAVOSH/Safety Program training conducted? Ref. OPNAVINST 4790.2G. Vol. V, para. 2.4 c	____	____

NUMBER		QUESTION	Yes	No
241 C	B	Are lesson guides reviewed at least annually, or sooner if system/component changes/modifications have occurred? Ref. OPNAVINST 4790.2G, Vol. V, para. 2.4 g(4)		
242 C	B	For large publications and instructions, do the Required Reading Cross Reference Locator Sheets have specific chapters/sections/paragraphs itemized? Ref. OPNAVINST 4790.2G, Vol. V, para. 2.4 f(2)		
243 C	B	Are ETS personnel used to complement MTU/FREST, MTIP, and shore based turnaround training, including classroom training and OJT? Ref. OPNAVINST 4790.2G, Vol. I, paras. 20.9 f(4) a and c	N/	A

APPENDIX D. SAMPLE VISUAL INFORMATION DISPLAY SYSTEM/MAINTENANCE ACTION FORM [5]

No. SWP 4826 COPY 1 5 PART FORM

WORK CENTER REGISTER, CONTROL AND PROCESSING COPY

USE BALL-POINT PEN PRESS HARD

VIDS/MAF OPNAV 4790/60 (REV.5-88) S/N 0107-LF-002-6900

ENTRIES REQUIRED SIGNATURE

NONE LOGS REC

☐ ☐ ☐

LOCAL USE

REFERENCE

ACCUMULATED WORK HOURS					ACCUMULATED AWM HOURS			
NAME/SHIFT	TOOL BOX	DATE	MAN HOURS	ELAPSED M/T	DATE	TIME	REASON	HOURS

(H-Z) FAILED/REQUIRED MATERIAL

79 INDEX	08 F/P	09 AWP	10 A/T	11 MAL	14 MFGR	19 PART NUMBER	34 REF SYMBOL	41 QTY	PROJ	43 PRI	45 DATE ORD	49 REQ NO	53 DATE REC
	☐	☐											
	☐	☐											
	☐	☐											
	☐	☐											
	☐	☐											
	☐	☐											
	☐	☐											

FOLD

A22 WORK UNIT CODE	A29 ACTION ORG	A32 TRANS	A34 MAINT L	A35 ACT TAKEN	A36 MAL CODE	A39 ITEMS P	A41 MAN HOURS	A46 ELAPSED M/T	F06 INTERIM	TECHNICAL DIRECTIVE IDENTIFICATION: F06 CODE	F11 BASIC NO	F15 RV	F16 AM	F17 PART	F18 KIT
4515W									☐						

A43 TYPE EQUIP	A42 BUNO/SER NUMBER	A50 DISCOV	A50 T/M	A60 POINT	A63 FID	A65 SAFETY/EI SER	A69 METER	E8 MFGR	A74	F21	F22 INVENTORY PERM UNIT CODE	F28
APBD	156516	0	G									

REPAIR CYCLE

	DATE	TIME	EOC
RECEIVED	B08	B12	B16
IN WORK	B19	B23	B27
COMPLETED	B30	B34	

AWAITING MAINTENANCE

B38	B39 HOURS	B42	B44 HOURS	B48	B49 HOURS

MAINTENANCE/SUPPLY RECORD

JOB STATUS	DATE	TIME	EOC
B63	B64	B68	B62
B65	B66	B70	B74
C08	C09	C13	C17
C20	C21	C25	C29
C32	C33	C37	C41
C44	C45	C49	C53
C56	C57	C61	C65
D08	D09	D13	D17

JOB CONTROL NUMBER

A08 ORG.	A11 DAY	A14 SER	A17 SUP	A19 WORK CENTER
AT5	190	A03		

REMOVED/OLD ITEM

E08 MFGR	E13 SERIAL NUMBER
12345	MULTI

E23 PART NUMBER	E38 DATE REMOVED
MS-123456-78	6190

E42 TIME/CYCLES	E47 TIME/CYCLES	E52 TIME/CYCLES
A1010		

INSTALLED/NEW ITEM

G08 MFGR	G13 SERIAL NUMBER

G23 PART NUMBER

G38 TIME/CYCLES	G43 TIME/CYCLES	G48 TIME/CYCLES

DISCREPANCY

CHECK & TEST (2) HYDRAULIC RETURN FILTERS IAW MRC's 105/106

SER # 4498 & 6306

PILOT/INITIATOR *AZCM STIFFLER*

CORRECTIVE ACTION

CF REQ ☐ QA REQ ☐

RFI BCM

CORRECTED BY	INSPECTED BY	SUPERVISOR	MAINT CONTROL

↑ ↓	MODEX	P R I	TURN-IN DOCUMENT	SYSTEM / REASON	M C N

APPENDIX E. SAMPLE STANDARD OPERATING PROCEDURES FROM THE T-45TS PROGRAM [33]

BEFORE ISO 9000

OBSOLETE

T45TS CLS
Volume II Attachment D
MI-032

T45TS
Kingsville

Maintenance Instruction

Number: 032

Issue Date: May 1995

Next Review Date (Mo/Yr): May 1996

Reviewing Skill Center: Quality Control

[illegible]
[illegible] NO. ______
[illegible] ______

QC Manager: [illegible]	Site Manager: [illegible]

SUBJECT: EMPLOYEE TRAINING, CERTIFICATION AND QUALIFICATION PROGRAM

REFERENCE: None

ENCLOSURES AND AUDITABLE DOCUMENTATION:
* (1) T45TS Training Attendance Form
* (2) T45TS Training Request
* (3) Training Request Process Flow Chart
(4) Employee Training Record
(5) Employee Certification Listing

I. PURPOSE: To ensure properly trained and qualified employees accomplish maintenance, servicing and/or operational tasks on aircraft, aircraft systems, ground training systems, components and support equipment, and those tasks or jobs requiring special skill training and proficiency levels for certification are performed by employees with those

OBSOLETE

"Obsolete" indicates that the document is no longer used. This document is reprinted with permission from the provider.

certifications. Skill training and testing will include the duration a complexity necessary to ensure employee performance meets MD standards and/or government regulations and may be a prerequisit employment.

II. APPLICATION: T45TS

NOTE:

Recertification of any qualification/certification/licensing is the responsibility of the appropriate manager (including CEO).

NOTE:

All training required will be scheduled through the Training Coordinator. Refer to encl (3) for Training Request Process Flow Chart.

III. RESPONSIBILITIES:

A. Site Manager will:

1. Be responsible for the Site's Employee Training, Certification and Qualification Program.
2. Sign the certification forms or delegate signature authority to the appropriate Managers as required, by letter.

B. Managers will:

1. Ensure employees are trained, qualified and certified as specified i applicable instructions and/or directives.
2. Ensure sufficient Professional Job Training (PJT) is accomplished satisfy the requirements of Certification/Qualification.
3. Ensure Team Leads coordinate training and certification requireme with the Employee Training Coordinator.
4. Ensure employees are trained, qualified and certified, in sufficient number, to accomplish tasking.
5. When authority is delegated sign certification(s) as required.

NOTE

Initial employee certifications may be based on employee's past experience, previously documented qualifications, documented for training/schools (either military, civilian equivalent or Contractor Logistics Support equivalent) and the completion of MDC's requirements for certification.

C. Team Leads will:

1. Ensure employees are provided training to obtain qualifications and certifications necessary to perform assigned tasking.

2. Complete Enclosure (1) upon completion of all training conducted.
3. Request and coordinate employee training requirements with Management and the Employee Training Coordinator using the T45TS Training Request Enclosure (2).
4. When notified, by the Employee Training Coordinator, requested training has been approved and a quota granted, ensure a travel request(s) is submitted to Business Operations for action.

D. Employee Training Coordinator will:

1. Schedule employee training as requested by team leads or managers.
2. Ensure copies of the training request are provided to applicable managers.
3. Establish and maintain employee training records.
4. Establish and maintain the computer data base for training.
5. Provide employee training schedule to the Maintenance Manager for inclusion in site monthly maintenance plan.
6. Keep management informed of Site Training Posture.

E. Quality Control will:

1. Manage the Employee Training, Certification and Qualification Program as required by applicable instructions or directives.
2. Assign a Training Coordinator to implement, coordinate, and manage the training requirements for T45 Training Systems (T45TS).
3. Coordinate with Managers and Team Leads on employee training requirements and assist as required.
4. Maintain the master copy and administer tests required for employee certification or qualification (excluding SE which will be administered by the Support Equipment Instructor and NDI which will be administered by the NDI Instructor).
5. Ensure employees achieve 80%, as a minimum, for a passing score.
6. Ensure employees achieve 90%, as a minimum, for a passing score on all retakes of tests. Retakes of initial tests may not be accomplished prior to 30 days from date of initial testing. Failure of any retake test will disqualify an employee for a period of six months or upon joint review and recommendation for reinstatement of employee qualifications by Quality Control and Production/Maintenance Managers.

IV. EMPLOYEE TRAINING

A. Training will be conducted on a continuing basis for all employees. Each employee will receive the training necessary to perform assigned tasking and maintain the quality standards required by the customer. Required training requests will be routed as illustrated in enclosure (3).

V. CERTIFICATION/QUALIFICATION OF EMPLOYEES:

A. Training courses will be provided for the employee. Upon completion of PJT, formal and/or hands-on, employees will be required to take and pass applicable certification test(s). Employees will be issued a Certification Card or letter, and/or a Quality Control Inspection Stamp. Certification/recertification is deemed necessary respective of the following requirements:

1. Critical nature of the task performed.
2. High degree of proficiency required.
3. Probable deterioration of skills with disuse.
4. Continuing changes in materials, procedures and repair methods.

B. The following include, but are not limited to, tasks/jobs/programs which require certification/qualification documentation:

1. Quality Control Inspector (QCI)
2. Collateral Duty Quality Control Inspector (CDQCI)
3. Collateral Duty Inspector (CDI)
4. Plane Captain
5. Non-nuclear Ordnance
6. Release Aircraft "Safe for Flight"
7. Weight and Balance
8. Shipboard Aircraft Firefighting
9. Engine Low/High Power Turn (Certified Engine Operator)
10. Nondestructive Inspection (by process)
11. Gas Free Engineering
12. Support Equipment Operator
13. Welding
14. Egress System/Environment Technician
15. Microminiature and Miniature Repair
16. Tire/Wheel Buildup and Maintenance Safety
17. Respirator Fit
18. Engine Test Cell Operator
19. Hydraulic Contamination
20. Final Checker
21. Corrosion Control
22. Aircraft Painter

23. Engine Debris Particle
24. Aviator's Breathing Oxygen
25. Brake Rider/Wing Walker
26. Fuel Surveillance
27. Personal Protective Equipment
28. Precision Measuring Equipment
29. Egress System Checkout
30. Closehole Tolerance Certification
31. Coldworking Certification

NOTE:

FOR THOSE CERTIFICATIONS/QUALIFICATIONS THAT HAVE EXPIRED AND THE EMPLOYEE HAS NOT RECEIVED THE RE-CERTIFICATION/QUALIFICATION/ TRAINING, A MEMO WILL BE SENT TO THE APPROPRIATE MANAGER/LEAD NOTIFYING THEM OF THE DISCREPANT AREA. QC WILL ALSO BE PROVIDED A COPY OF THIS MEMO.

NOTE:

FOR THOSE CERTIFICATIONS/QUALIFICATIONS THAT HAVE EXPIRED AND THE EMPLOYEE HAS NOT RECEIVED THE RE-CERTIFICATION/QUALIFICATION/ TRAINING, A MEMO WILL BE SENT TO THE APPROPRIATE MANAGER/LEAD NOTIFYING THEM OF THE DISCREPANT AREA. QC WILL ALSO BE PROVIDED A COPY OF THIS MEMO.

T45TS TRAINING ATTENDANCE SHEET

Subject: ____________________

Instructor: ____________ Date: ____________

Time (In Hrs): _____ PJT: _____ Formal: _____ Quarterly: ____

JICC used: ____________

Attendee's Name	Employee #	Work Area

Enclosure (1)

MI-032

T45TS
TRAINING REQUEST

Employee Name: ________________
Employee #: ____________________
JICC to be used: _____________

Special Training Requested	Scheduled Training Date
____________________________________	________________________
____________________________________	________________________
____________________________________	________________________
____________________________________	________________________
____________________________________	________________________

Team Lead: __________________ Group/Unit Manager: ______________

Manager: ______________________________

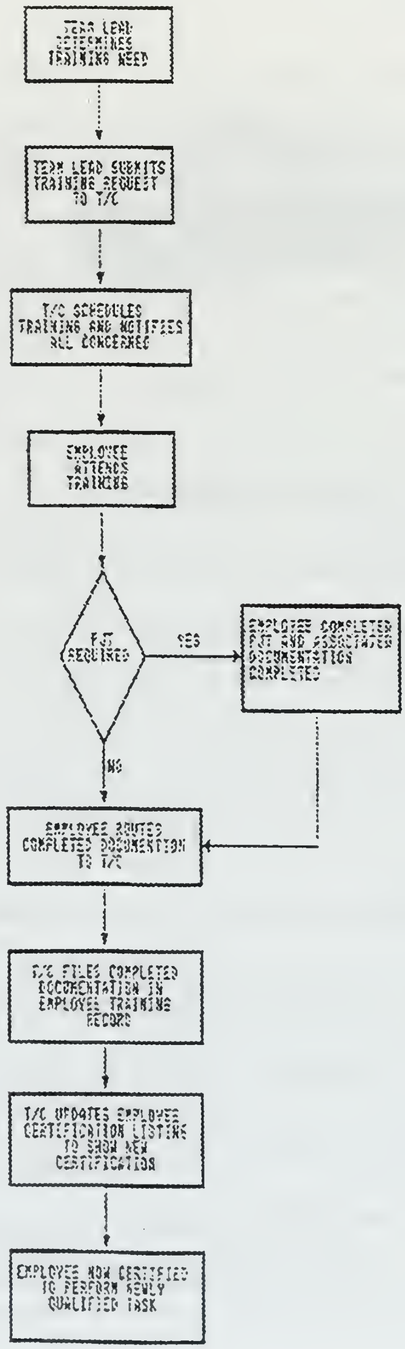
Employee Training: ___________________

Instructor: __________________________

Original: Employee Training Coordinator

Copy to: Team Lead/Individual Instructor

Enclosure (2)



TRAINING REQUEST PROCESS FLOW CHART

T45TS
Kingsville

Standard Operating Procedure

Number: 032

Issue Date: January 1997

Next Review Date (Mo/Yr): January 1998

Reviewing Skill Center: Training Coordinator

Component Repair and Maintenance Control Managers:	Aircraft Support Manager:

SUBJECT: EMPLOYEE TRAINING, CERTIFICATION AND QUALIFICATION PROGRAM

REFERENCE: None

ENCLOSURES AND AUDITABLE DOCUMENTATION:

- * (1) T45TS Training Attendance Form
- * (2) T45TS Training Request
- * (3) Training Request Process Flow Chart
- (4) Employee Training Record
- (5) Employee Certification Listing

I. PURPOSE: To ensure properly trained and qualified employees accomplish maintenance, servicing and/or operational tasks on aircraft, aircraft systems, ground training systems, components and support equipment, and those tasks or jobs requiring special skill training and proficiency levels for certification are performed by employees with those certifications. Skill training and testing will include the duration and complexity necessary to ensure employee performance meets MDC standards and/or government regulations and may be a prerequisite of employment.

II. APPLICATION: T45TS

NOTE:

Recertification of any qualification/certification/licensing is the responsibility of the appropriate manager.

NOTE:

All training required will be scheduled through the Training Coordinator. Refer to enclosure (3) for Training Request Process Flow Chart.

III. RESPONSIBILITIES:

A. Aircraft Support Manager will:

1. Be responsible for the department's Employee Training, Certification and Qualification Program.
2. Sign the certification forms or delegate signature authority to the appropriate Managers as required, by letter.

B. Managers will:

1. Ensure employees are trained, qualified and certified as specified in applicable instructions and/or directives.
2. Ensure sufficient Professional Job Training (PJT) is accomplished to satisfy the requirements of Certification/Qualification.
3. Ensure Team Leads coordinate training and certification requirements with the Employee Training Coordinator.
4. Ensure employees are trained, qualified and certified, in sufficient number, to accomplish tasking.
5. When authority is delegated sign certification(s) as required.

NOTE

Initial employee certifications may be based on employee's past experience, previously documented qualifications, documented formal training/schools (either military, civilian equivalent or Contractor Logistics Support equivalent) and the completion of MDC's requirements for certification.

C. Team Leads will:

1. Ensure employees are provided training to obtain qualifications and certifications necessary to perform assigned tasking.

2. Complete Enclosure (1) upon completion of all training conducted.
3. Request and coordinate employee training requirements with Management and the Employee Training Coordinator using the T45TS Training Request Enclosure (2).
4. When notified, by the Employee Training Coordinator, requested training has been approved and a quota granted, ensure a travel request(s) is submitted to Business Operations for action.

D. Employee Training Coordinator will:

1. Schedule employee training as requested by team leads or managers.
2. Ensure copies of the training request are provided to applicable managers.
3. Establish and maintain employee training records.

4. Establish and maintain the computer data base for training.
5. Provide employee training schedule to the Maintenance Manager for inclusion in site monthly maintenance plan.
6. Keep management informed of Site Training Posture

E. Quality Control will:

1. Monitor the training program in accordance with this SOP.
2. Coordinate with Managers and Team Leads on employee training requirements and assist as required.
3. Maintain the master copy and administer tests required for employee certification or qualification (excluding SE which will be administered by the Support Equipment Instructor and NDI which will be administered by the NDI Instructor).
4. Ensure employees achieve 80%, as a minimum, for a passing score.
5. Ensure employees achieve 90%, as a minimum, for a passing score on all retakes of tests. Retakes of initial tests may not be accomplished prior to 30 days from date of initial testing. Failure of any retake test will disqualify an employee for a period of six months or upon joint review and recommendation for reinstatement of employee qualifications by Quality Control and Production/Maintenance Managers.

IV. EMPLOYEE TRAINING

A. Training will be conducted on a continuing basis for all employees. Each employee will receive the training necessary to perform assigned tasking and maintain the quality standards required by the customer. Required training requests will be routed as illustrated in enclosure (3).

V. CERTIFICATION/QUALIFICATION OF EMPLOYEES:

A. Training courses will be provided for the employee. Upon completion of PTT, formal and/or hands-on, employees will be required to take and pass applicable certification test(s). Employees will be issued a letter and/or a Quality Control Inspection Stamp. Certification/recertification is deemed necessary respective of the following requirements:

1. Critical nature of the task performed.
2. High degree of proficiency required.
3. Probable deterioration of skills with disuse
4. Continuing changes in materials, procedures and repair methods.

B. The following include, but are not limited to, tasks/jobs/programs which require certification/qualification documentation:

1. Quality Control Inspector (QCI)
2. Collateral Duty Quality Control Inspector (CDQCI)
3. Collateral Duty Inspector (CDI)
4. Plane Captain
5. Ordnance Certification
6. Release Aircraft "Safe for Flight"
7. Weight and Balance
8. Engine Low/High Power Turn (Certified Engine Operator)
9. Nondestructive Inspection (by process)
10. Gas Free Engineering
11. Support Equipment Operator
12. Welding

13. Egress System/Environment Technician
14. Microminiature and Miniature Repair
15. Tire/Wheel Buildup and Maintenance Safety
16. Respirator Fit
17. Engine Test Cell Operator
18. Hydraulic Contamination
19. Corrosion Control, Aircraft Painter
20. Engine Debris Particle
21. Aviator's Breathing Oxygen
22. Brake Rider/Wing Walker
23. Fuel Surveillance
24. Personal Protective Equipment Tech
25. Precision Measuring Equipment
26. Egress System Checkout

NOTE:

FOR THOSE CERTIFICATIONS/QUALIFICATIONS THAT HAVE EXPIRED AND THE EMPLOYEE HAS NOT RECEIVED THE RE-CERTIFICATION/QUALIFICATION/ TRAINING, A MEMO WILL BE SENT TO THE APPROPRIATE MANAGER/LEAD NOTIFYING THEM OF THE DISCREPANT AREA. QC WILL ALSO BE PROVIDED A COPY OF THIS MEMO.

T45TS TRAINING ATTENDANCE SHEET

Subject: ____________________

Instructor: ____________ Date: ____________

Time (In Hrs): ____ PJT: ____ Formal: ____ Quarterly: ____

JICC used: ________

Attendee's Name	Employee #	Work Area

Enclosure (1)

T45TS
TRAINING REQUEST

Employee Name: ____________
Employee #: ____________
JICC to be used: ____________

Special Training Requested	**Scheduled Training Date**
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________

Team Lead: ____________ Group/Unit Manager: ____________

Manager: ____________

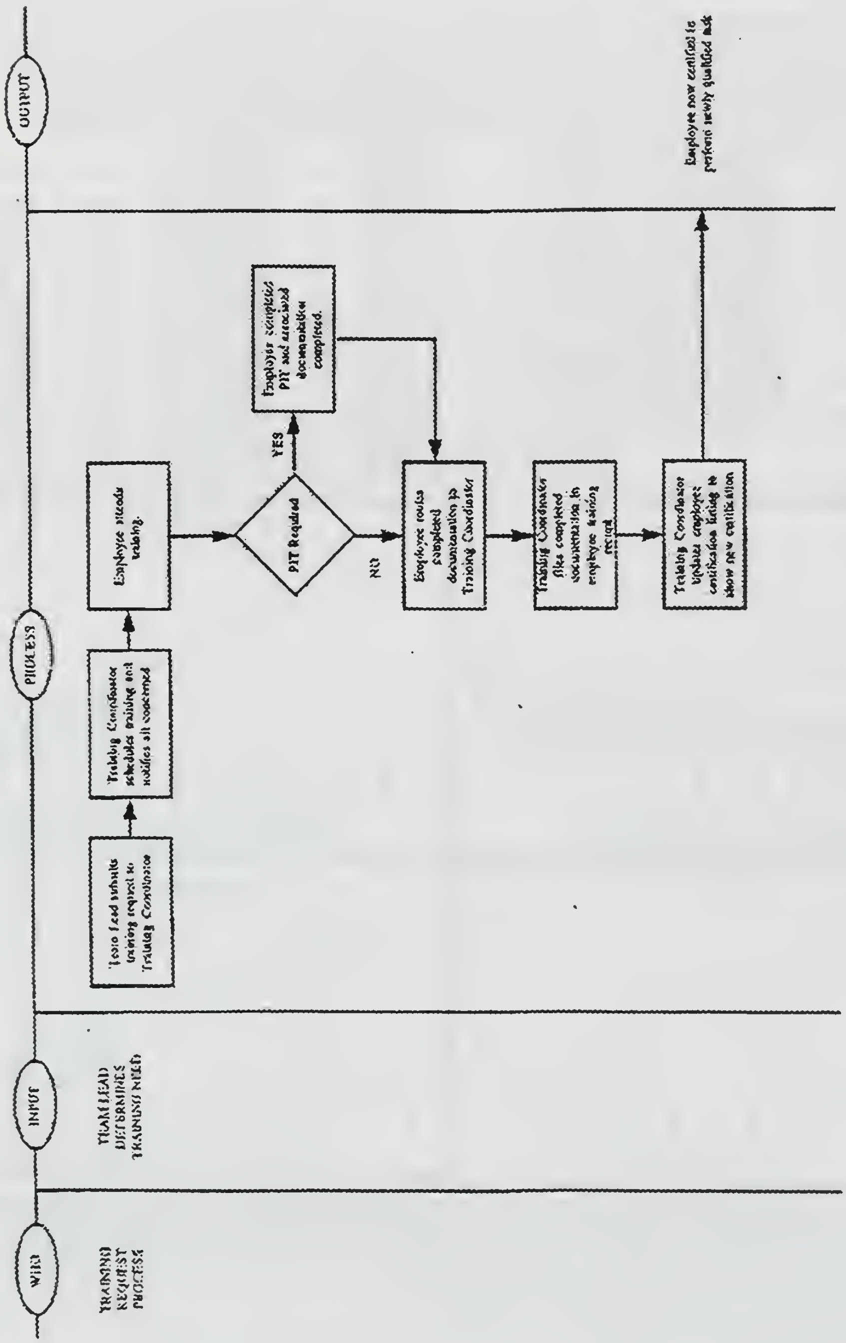
Employee Training: ____________

Instructor: ____________

Original: Employee Training Coordinator

Copy to: Team Lead/Individual Instructor

Enclosure (2)


WHO
INPUT
PROCESS
OUTPUT
TRAINING REQUEST PROCESS
TEAM LEAD DETERMINES TRAINING NEED
Team Lead submits training request to Training Coordinator
Training Coordinator schedules training and notifies all concerned
Employee attends training.
PIT Required
YES
NO
Employee completes PIT and associated documentation completed.
Employee routes completed documentation to Training Coordinator
Training Coordinator files completed documentation in employee training record
Training Coordinator updates employee certification listing to show new certification
Employee now certified to perform newly qualified task

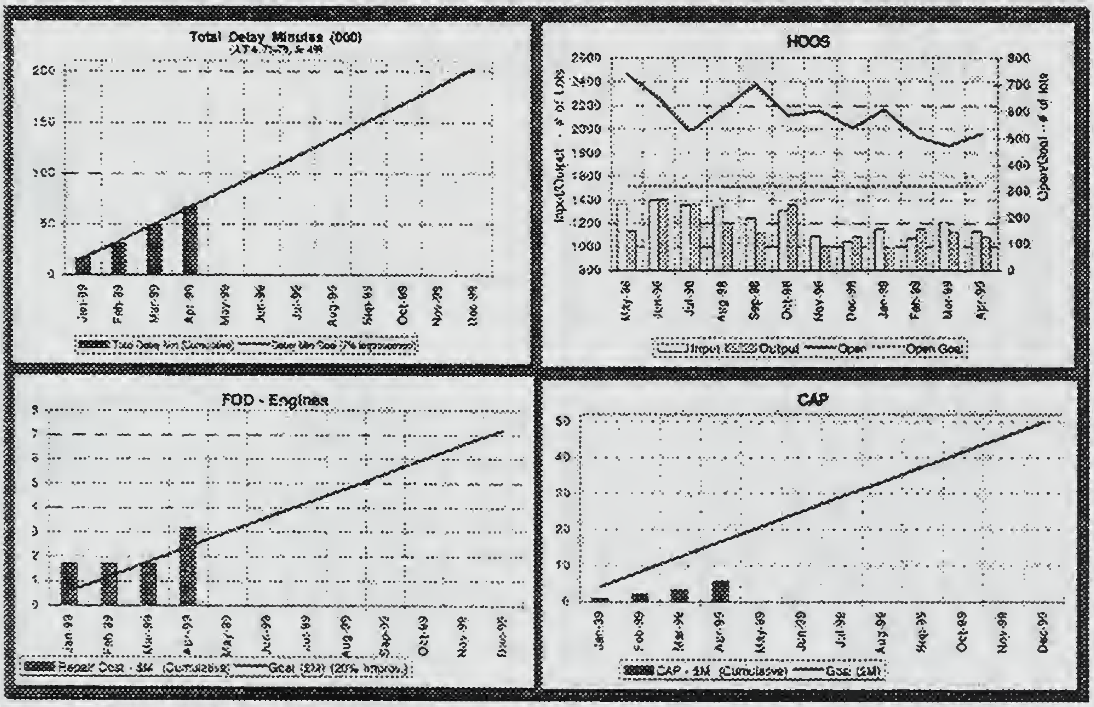
Enclosure (3)

APPENDIX F. SAMPLE STATISTICAL TECHNIQUES/CHARTS [25]

Powerplant Engr Dashboard April 1999

Inflight Shutdowns, Planned Removals, Shop Visit Rates, Service Bulletins

	[illegible]		[illegible]		[illegible]		[illegible]			
Engine Type	GOAL	[illegible]	GOAL	[illegible]	GOAL	[illegible]	TOTAL	[illegible]	% Improv. Goal Month-Month	[illegible]
System	0.011	[illegible]	71%	[illegible]	0.107	[illegible]	1299	1072	9%	2%
V2500	0.007	[illegible]	47%	[illegible]	0.057	0.056	[illegible]	[illegible]	10%	[illegible]
JT8D	0.011	[illegible]	61%	58%	0.176	[illegible]	[illegible]	[illegible]	10%	[illegible]
CFM	0.004	[illegible]	74%	69%	0.121	0.104	[illegible]	[illegible]	10%	[illegible]
PW4056	0.011	[illegible]	75%	[illegible]	0.064	0.072	614	525	5%	[illegible]
PW4060	0.014	[illegible]	75%	68%	See PW4056					
PW4070/90	0.015	[illegible]	76%	73%	0.066	[illegible]				
JT9D 7A/J	0.049	[illegible]	71%	[illegible]	0.227	[illegible]	[illegible]	[illegible]	10%	[illegible]
JT9D 7R4D	0.014	[illegible]	71%	[illegible]	0.216	0.143				
PW2000	0.004	0.006	74%	[illegible]	0.128	0.141	114	104	10%	2%
CF6 - 6	0.046	[illegible]	55%	[illegible]	0.208	[illegible]	N/A	N/A	N/A	N/A
CF6 - 50	0.023	0.025	78%	[illegible]	0.178	[illegible]				



Key Projects

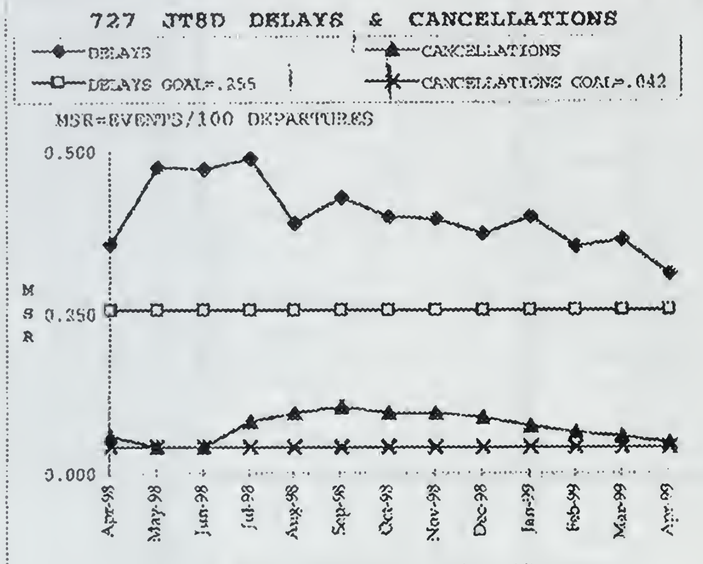
[illegible]	PW4090 Engine Stability Issues
CFM56 Transient EGT Gauge (Awaiting Master Change)	PW4056/60 Phase III
V2500 VSV Lever Arm Mod 2	PMA Project
PW4052/56/60 Engine Stability Issues (AD)	PW2000 LPT Vibration/Build
PW4077/90 LPT Airseal Cracks	JT8D : Hush Kitting , Fuel Nozzle bsro. inspection
HVOF substitute for Feltmetal-DER repair, Pratt Test	CFM56 FF Transmitter Replacement

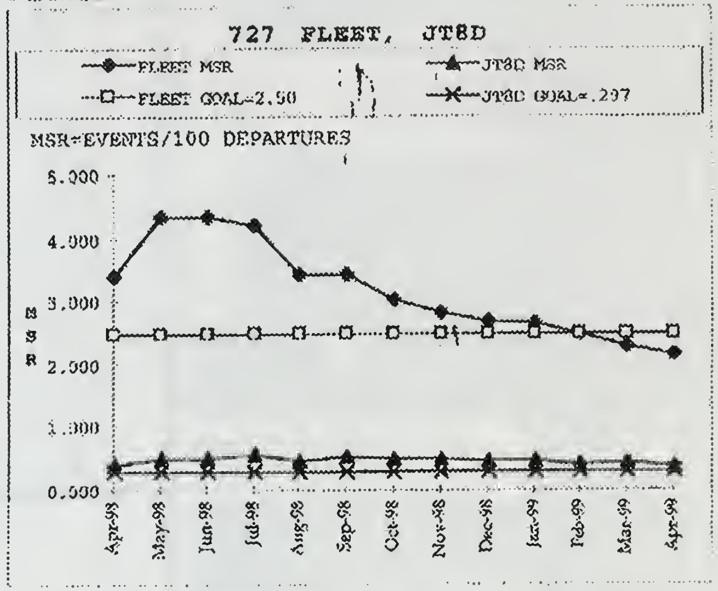
Published: 5/13/99

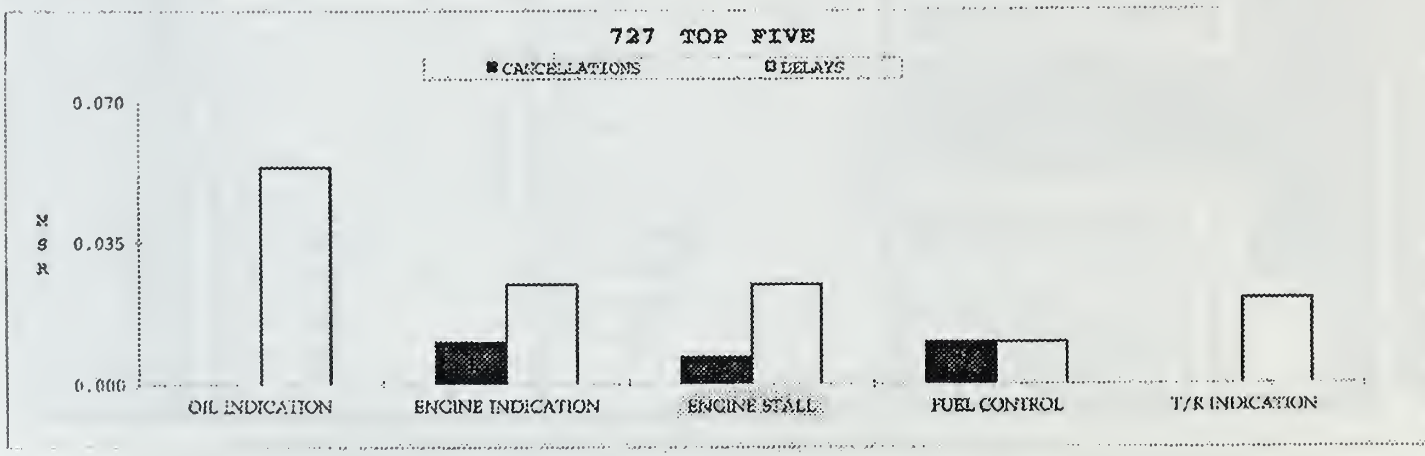
Green - On Target
Yellow - Potential Impact
Red - Unresolved Problems

727 JT8D APR, 1999

JT8D TOP FIVE MSR





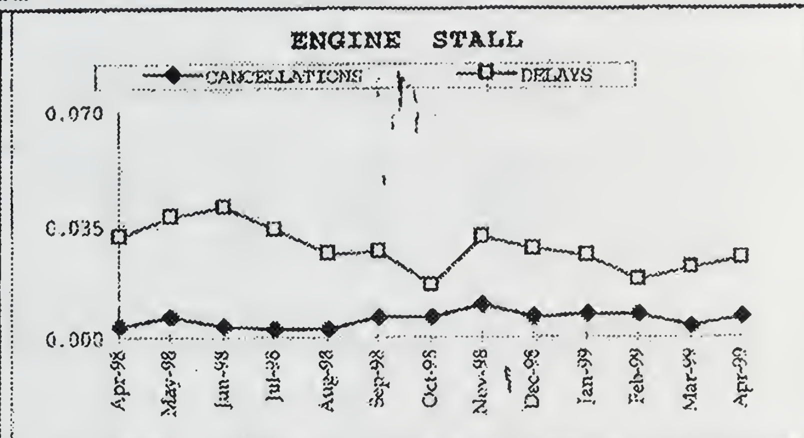


727 JT8D APR, 1999

ENGINE STALL

PROBLEMS / ISSUES

- High cross winds continue to be the major cause for compressor stalls, especially in the number two position. A few other Off-Idle stalls are caused by a malfunction of the antisurge bleed system, the FCU , F&D valve calibration, or deterioration of the rear compressor aerodynamics.



ACTIONS / ISSUES	WHO	WHEN
The shop limits for compressor blades have been tightened to improve the overall compressor performance. Short chord blades are being sold as surplus and replaced with new blades.	Bijan Katani	On Going
SFOEP is in the process of optimizing the High Pressure Turbine (HPT) and Low Pressure Turbine Stage 2 (T2) nozzle guide vane areas to improve the relationship between N1 and N2 rotor speeds.	Jack Kalfayan	COA 7-9071 On Going

Module Analysis Program III (Version 7.10 1)

Test Description: REPAIR
Owner: RIS Engine Model: V2500-A5
Test Cell: 2 Oper: LH AJF: 0.000
Test Configuration: BARE

Serial Number: 10048 Test Date: 12/13/87 Report Date: 01/13/88
Fuel LHV: 18585.00 Total Hours: 8812 Total Cycles: 3483
Baseline: V2527-A5 AR PROD BASE S/N V10028-V10074,W DEP Class: 7
Adjustments:

Recursive/zero sensor prior estimate analysis

**************************** Engine Module Assessments ****************************

FAN EFF PTS	FAN FCAP %	LPC EFF PTS	LPC FCAP %	HPC EFF PTS	HPC FCAP %	HPT EFF PTS	EFF A4 %	LPT EFF PTS	EFF A45 %	EFF AJE %
-0.3	-0.3	-0.3	-0.5	-0.8	0.1	-1.3	0.7	-0.2	0.1	0.0

**************************** Sensor Error Assessments ****************************

T25ER %	T3ER %	T49ER %	P25ER %	PS3ER %	N1ER %	N2ER %	FNER %	WFER %	P125ER %	P2ER %	T2ER %	P49ER %
0.1	0.1	-0.3	-0.1	0.0	0.0	-0.1	-0.2	0.3	0.0	0.2	0.3	-0.2

**************************** Module Contributions ****************************

			FAN	LPC	HPC	HPT	LPT	AJE	Total
DELTA TSFC	%	FN=K, Cruise	0.1	0.1	0.5	1.2	0.1	0.0	2.1
DELTA FN	%	EPR=K, Takeoff	-0.1	0.1	0.0	0.0	-0.1	0.0	-0.1
DELTA WF	%	EPR=K, Takeoff	0.0	0.2	0.7	1.5	0.1	0.0	2.4
DELTA EGT	DEGC	EPR=K, Takeoff	-0.8	1.4	8.7	14.2	0.7	0.0	22.4
DELTA LPC	O/L %	WAE=K, Cruise	0.5	-0.4	1.2	2.5	-0.3	0.0	3.8
DELTA HPC	O/L %	WAE=K, Cruise	0.0	0.0	0.7	0.6	-0.1	0.0	1.3

**************************** Measured Parameter Deltas (Normalized) Relative To Baseline ****************************

POINT NUMBER		3	2	1
TIME OF POINT		3.	2.	1.
P49/P2		1.331	1.478	1.555
T25/OT2 0.930	DEGK	2.25	3.17	4.00
T3/OT3 0.922	DEGK	0.66	1.55	2.73
T49/OT2 1.050	DEGK	22.38	22.35	22.44
P25/P2	%	1.98	2.87	2.92
PS3/P49	%	-1.29	-1.30	-1.02
NLR2A	%	0.11	0.42	0.38
NH2A	%	-0.85	-0.79	-0.49
FN/ST2	%	0.18	0.22	0.18
WFC2_LHV	%	3.39	4.08	3.65
P125/P2	%	-0.10	-0.18	0.01

WF and TSFC are normalized to LHV 18400. BTU/LB. (U087-C8)

Module Analysis Program III (Version 7.10 1)

Test Description: WATER WASH RUN ACCOMPLISHED	Serial Number: 10024	Test Date: 03/08/88	Report Date: 05/25/88
Owner: RIS Engine Model: V2500-A5	Fuel LHV: 18687.00	Total Hours: 11884	Total Cycles: 4812
Test Cell: 2 Oper: LK AJF: 0.000	Baseline: V2527-A5 RR PROD BASE S/N V10025-V10074,W		DEP Class: 8
Test Configuration: BARE	Adjustments:		

Recursive/zero sensor prior estimate analysis

** Engine Module Assessments **

FAN EFF PTS	FAN FCAP %	LPC EFF PTS	LPC FCAP %	HPC EFF PTS	HPC FCAP %	HPT EFF PTS	EFF A4 %	LPT EFF PTS	EFF A45 %	EFF AJE %
-0.2	-0.1	-0.3	-0.4	-1.1	-0.1	-0.2	-0.1	-0.7	1.1	0.0

** Sensor Error Assessments **

T25ER %	T3ER %	T49ER %	P25ER %	PS3ER %	N1ER %	N2ER %	FNER %	WFER %	P125ER %	P2ER %	T2ER %	P49ER %
0.3	0.2	-0.1	-0.3	0.2	0.0	-0.1	-0.2	0.0	0.3	0.5	-0.4	-0.2

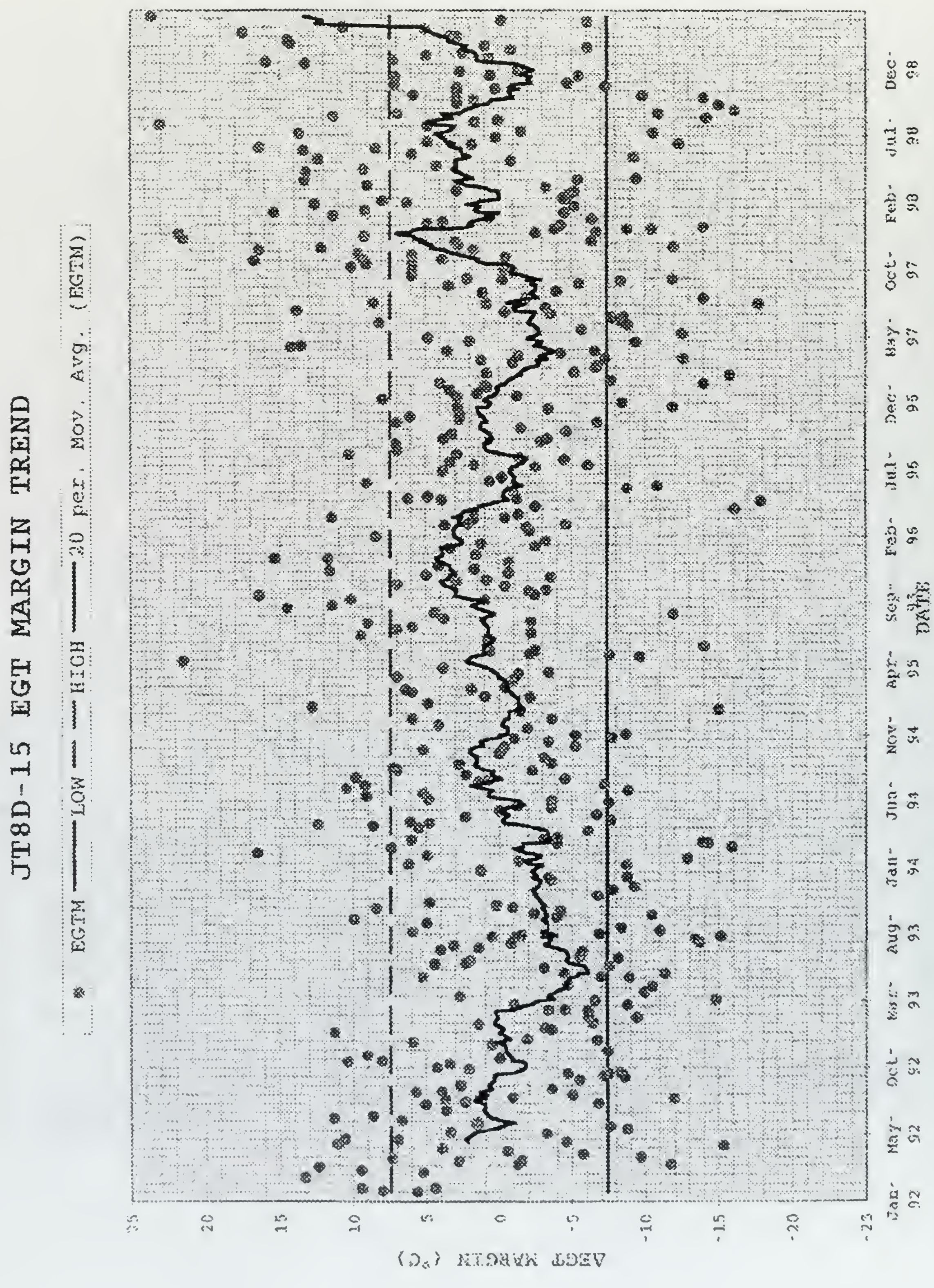
** Module Contributions **

		FAN	LPC	HPC	HPT	LPT	AJE	Total
DELTA TSFC %	FN=K, Cruise	0.1	0.1	0.7	0.1	0.8	0.0	1.8
DELTA FN %	EPR=K, Takeoff	-0.1	0.1	0.0	0.0	-0.6	0.0	-0.5
DELTA WF %	EPR=K, Takeoff	0.0	0.1	0.9	0.2	0.1	0.0	1.4
DELTA EGT DEGC	EPR=K, Takeoff	-0.1	1.3	8.5	1.7	1.8	0.0	13.2
DELTA LPC O/L %	WAE=K, Cruise	0.1	-0.3	1.5	0.3	-1.8	0.0	-0.2
DELTA HPC O/L %	WAE=K, Cruise	0.0	0.0	0.8	0.3	-0.4	0.0	0.8

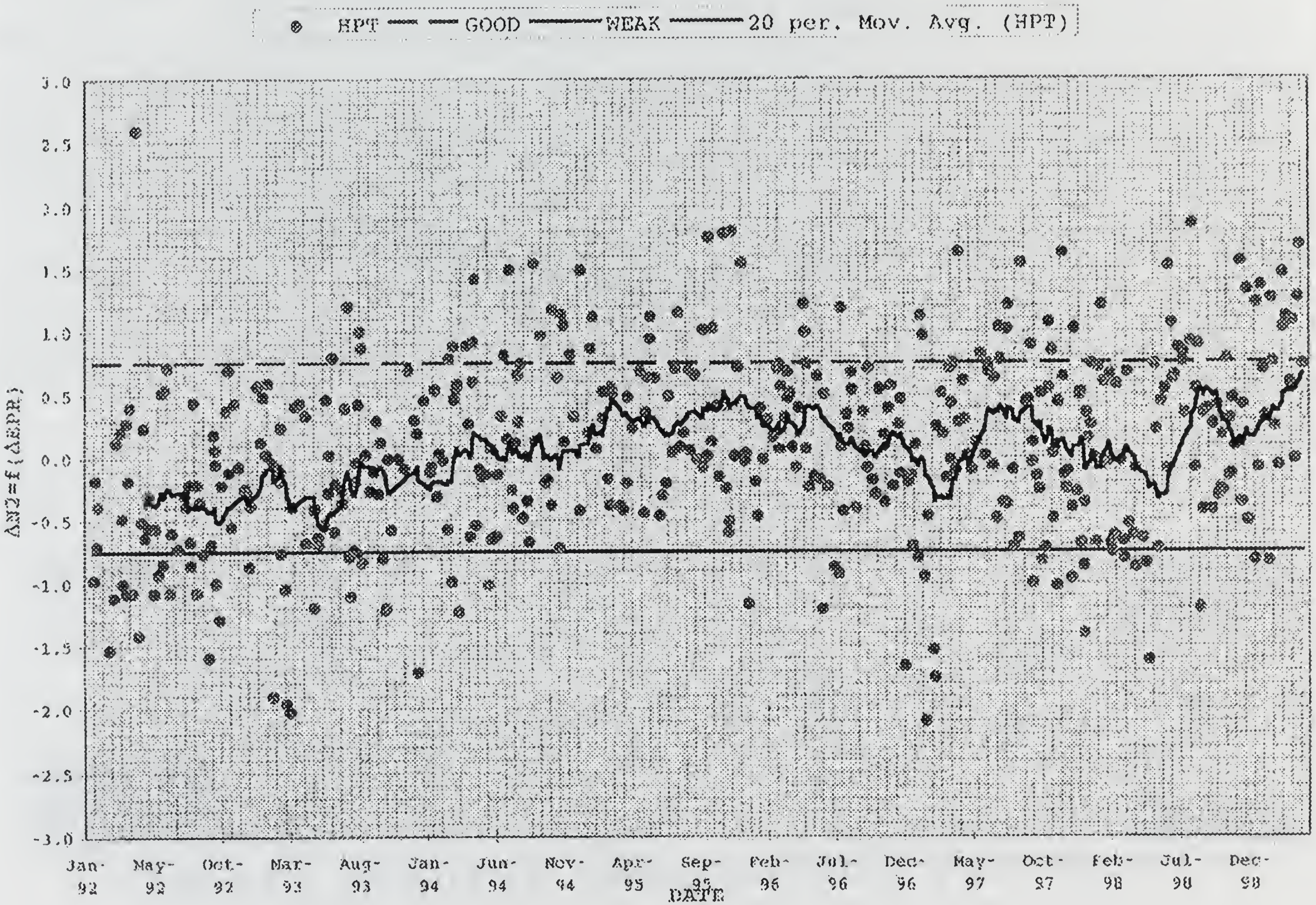
************************************ Measured Parameter Deltas (Normalized) Relative To Baseline ***************************************

		3	2	1
POINT NUMBER		3	2	1
TIME OF POINT		3.	2.	1.
P49/P2		1.337	1.481	1.557
T25/OT2 0.920	DEGK	1.87	2.84	2.66
T3/OT3 0.922	DEGK	8.82	9.81	12.55
T49/OT2 1.050	DEGK	15.87	17.67	17.69
P25/P2	%	0.28	0.16	-0.74
PS3/P49	%	0.59	0.64	0.73
XLR2A	%	-0.13	0.15	0.12
NHR2A	%	-0.58	-0.18	0.19
FN/S12	%	-0.92	-0.40	-0.42
WFC2_LHV	%	2.07	2.24	2.30
P125/P2	%	-0.08	0.05	0.20

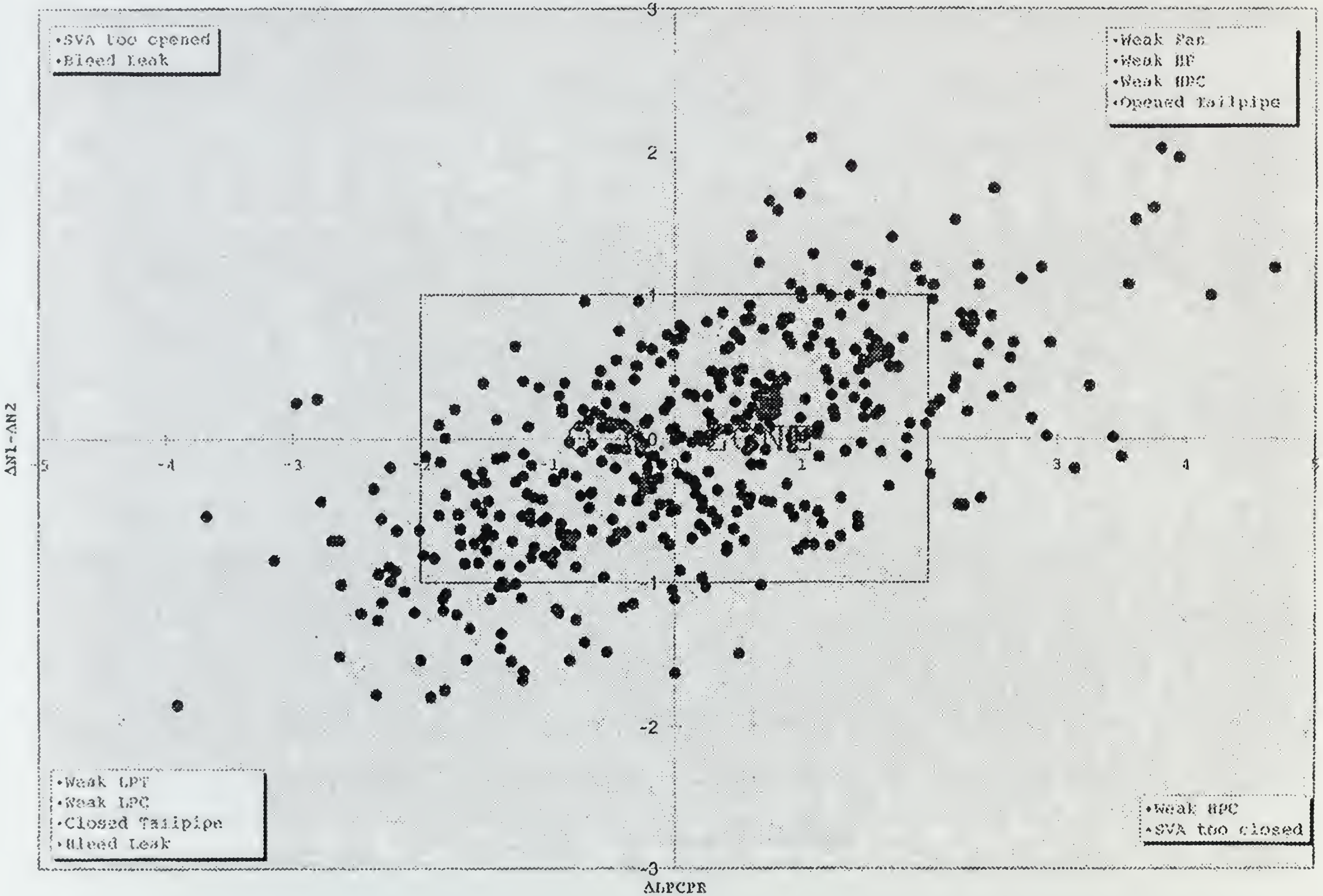
WF and TSFC are normalized to LHV 18400. BTU/LB. (U097+09)


JT8D-15 EGT MARGIN TREND
EGTM
LOW
HIGH
30 per. Mov. Avg. (EGTM)
ΔEGT MARGIN (°C)
DATE

JT8D-15 HPT MODULE



JT8D-15 Modular Performance Assessment



JT8D-15 MODULAR ANALYSIS

ENGINE S/N: 696582 ORDER: J459 REPAIR TYPE: Min

MODEL: 15 CELL #: 2 DATE: 3/23/99

BASELINE:

EPR	EGT °C	WF PPH	N2 RPM	N1 RPM	FN LBS	LPCPR P3/2	HPCPR P4/3	TPR P4/7	CPR P4/2	TSFC	PCEL "HG	PS3 "HG	PS4 "HG	PT7 "HG	PCB/4 "HG	PCP "HG	PBR "HG
1.830	497	7074	11035	7503	12490	3.061	4.324	7.063	12.923	0.570	29.96	92.7	387.3	53.8	0.5	203.9	4.0
1.950	520	8001	11238	7794	13750	3.284	4.305	7.246	14.134	0.581	29.95	98.4	423.3	56.4	0.5	222.4	4.5
2.116	554	9360	11521	8219	15500	3.692	4.397	7.482	15.933	0.604	29.95	107.9	474.2	63.4	0.5	238.0	5.4

BASELINE SHIFTED VALUES:

EPR	EGT °C	WF PPH	N2 RPM	N1 RPM	FN LBS	LPCPR P3/2	HPCPR P4/3	TPR P4/7	CPR P4/2	TSFC	PCEL "HG	PS3 "HG	PS4 "HG	PT7 "HG	PCB/4 "HG	PCP "HG	PBR "HG
1.831	497	7078	11036	7504	12497	3.062	4.224	7.064	12.934	0.570	29.96	92.7	387.4	54.8	0.5	204.0	4.0
1.952	520	7998	11238	7793	13747	3.284	4.394	7.246	14.131	0.581	29.95	98.4	423.2	58.4	0.5	223.3	4.5
2.124	554	9342	11517	8214	15478	3.598	4.396	7.479	15.830	0.604	29.95	107.7	473.5	62.5	0.5	247.6	5.4

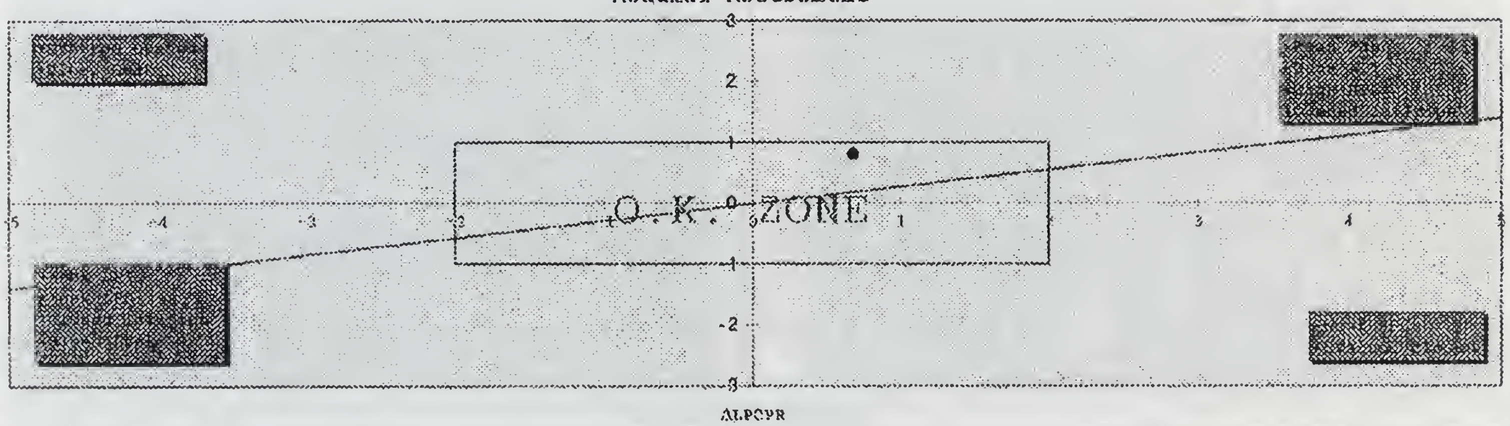
ACTUAL ENGINE:

EPR	EGT °C	WF PPH	N2 RPM	N1 RPM	FN LBS	LPCPR P3/2	HPCPR P4/3	TPR P4/7	CPR P4/2	TSFC	PCEL "HG	PS3 "HG	PS4 "HG	PT7 "HG	PCB/4 "HG	PCP "HG	PBR "HG
1.831	497	7130	10920	7497	12400	3.070	3.261	7.144	13.050	0.575	30.00	92.1	392.4	54.9	0.3	203.6	1.7
1.950	517	8017	11092	7768	13750	3.293	4.335	7.318	14.270	0.582	30.00	98.8	428.1	58.5	0.5	221.1	1.8
2.134	545	9300	11332	8148	15500	3.622	4.405	7.547	15.991	0.600	30.00	105.6	476.5	63.4	0.5	245.8	2.1

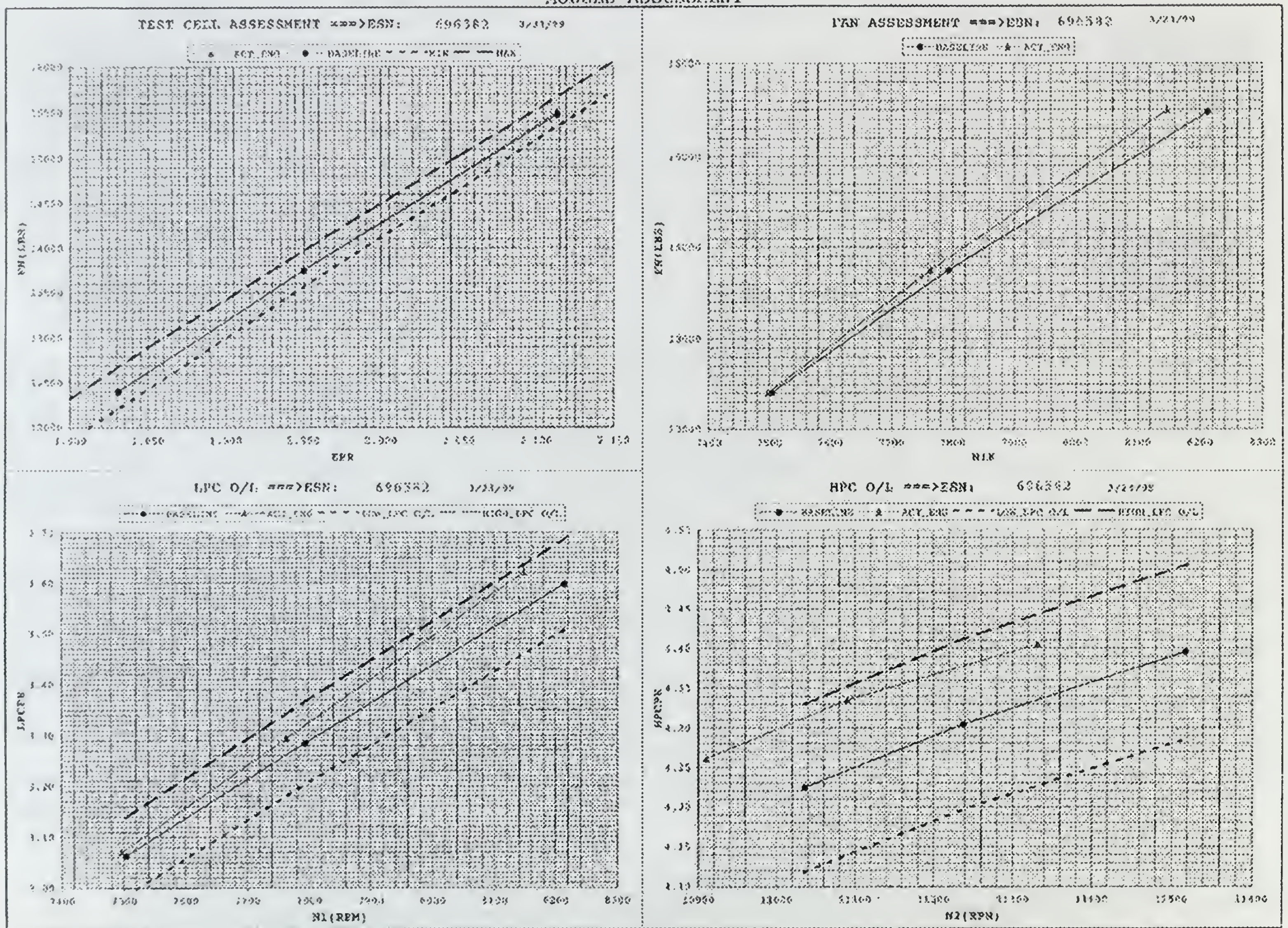
DEVIATIONS:

AN1-AN2 %	EGT Δ°C	WF %Δ	N2 %Δ	N1 %Δ	FN %Δ	LPCPR %Δ	HPCPR %Δ	TPR %Δ	CPR %Δ	TSFC %Δ	PCEL %Δ	PS3 %Δ	PS4 %Δ	PT7 %Δ	PCB/4 %Δ	PCP %Δ	PBR %Δ
1.1	0.1	0.7	-1.1	-0.1	-0.1	0.3	0.9	1.1	1.1	0.8	0.1	0.4	1.3	0.1	-1.4	-0.2	-58.6
0.9	-3.3	0.2	-1.3	-0.4	0.0	0.3	0.7	1.0	1.0	0.2	0.2	0.5	1.1	0.2	-1.8	-0.5	-59.7
0.8	-9.0	-0.4	-1.6	-0.8	0.1	0.7	0.2	0.9	0.9	-0.6	0.2	0.6	1.1	0.1	-1.7	-0.7	-60.6

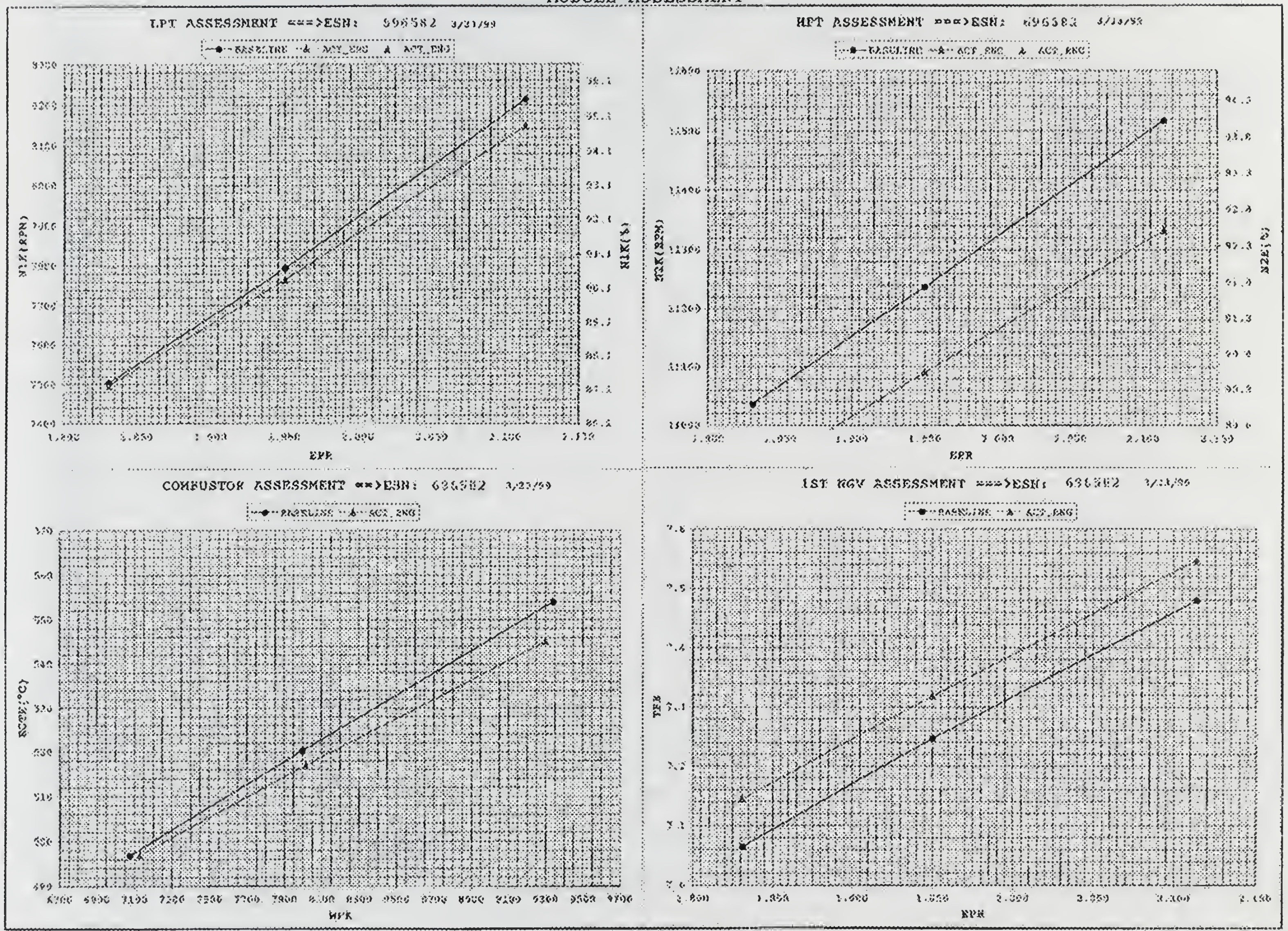
Modular Assessment



MODULE ASSESSMENT



MODULE ASSESSMENT

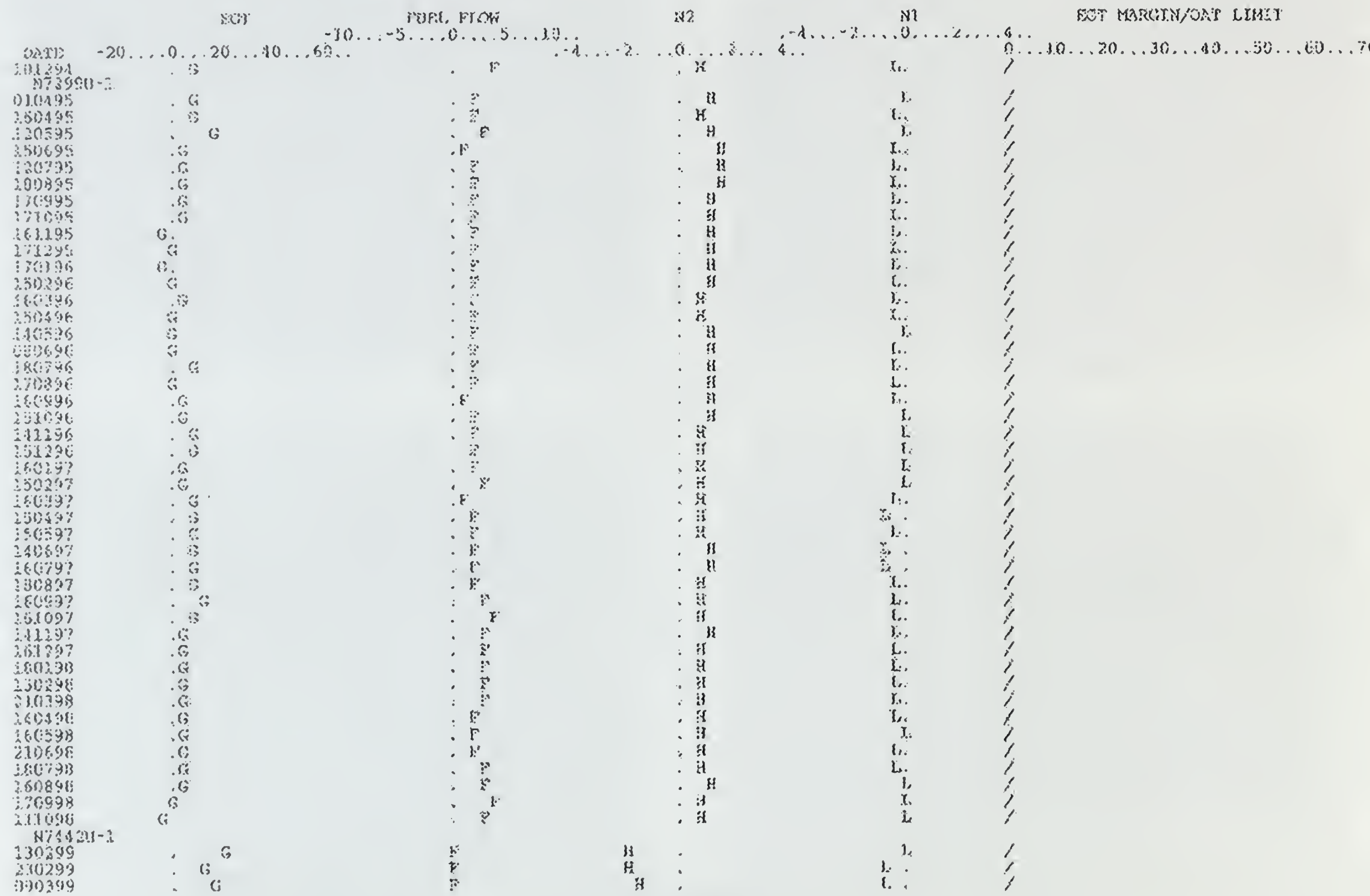


COMPRESSED HISTORY REPORT

ECM PLOTS

RUN DATE 17/04/99

696582 JT8D-15 N7297U-1

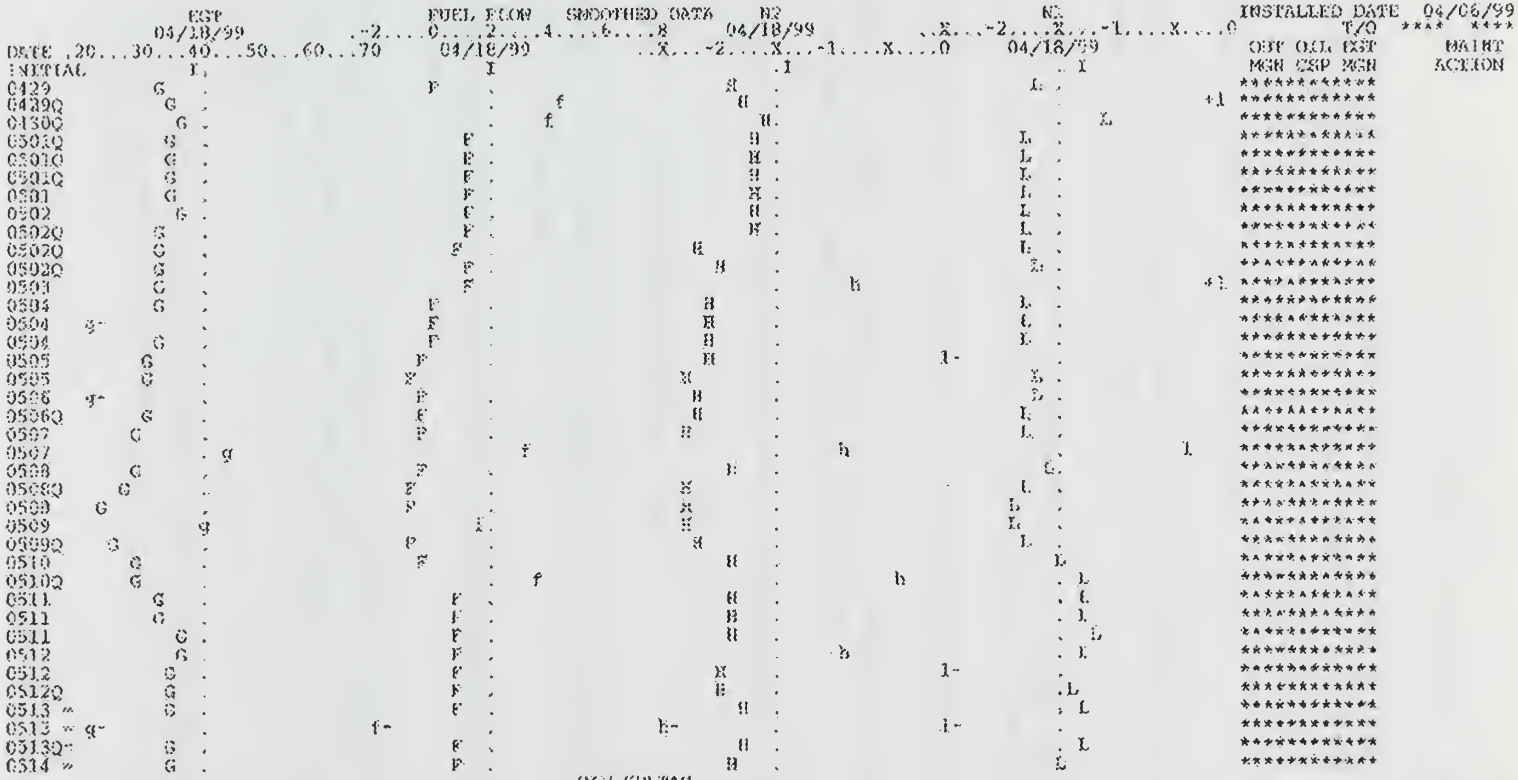


ECM PLOTS

RUN DATE 05/14/99

696582 JT8D-15   810   N7297U-1   727-200A

INSTALLED DATE 04/06/99



OIL PRS	OIL TMP	AVE L	AVM B	EFF POS
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49.	0.	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0
50	0	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0
50.	0.	0.0	0.0	0.0

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